

A COMPANION TO
MANUALS OF
PRACTICAL ANATOMY

E. B. JAMIESON

OXFORD
MEDICAL PUBLICATIONS



PRESS MARK

Press No. Fa*
Shelf No. 2
Book No. 13

R37263



Digitized by the Internet Archive
in 2015

<https://archive.org/details/b21701271>

COMPANION

TO

MANUALS OF PRACTICAL ANATOMY

PUBLISHED BY THE JOINT COMMITTEE OF HENRY FROWDE AND HODDER & STOUGHTON
AT THE OXFORD PRESS WAREHOUSE, FALCON SQUARE, LONDON, E.C.

A COMPANION
TO
MANUALS
OF PRACTICAL ANATOMY

BY

E. B. JAMIESON, M.D.

SENIOR DEMONSTRATOR AND LECTURER IN ANATOMY
UNIVERSITY OF EDINBURGH

BIBLIOTH
COLL. REG.
MED. EDIN.

EDINBURGH, GLASGOW, AND LONDON
HENRY FROWDE AND HODDER & STOUGHTON

1913

PREFACE

THIS book has been written to provide, in an easily portable form, an account of naked-eye Anatomy, expressed in terms of the Basle nomenclature.

To ensure comprehensiveness, and to avoid the extensive use of small type, it has been necessary to employ very condensed language, and to shorten some of the terms that frequently occur; *e.g.*, *inferior* is contracted into *inf.*, and *external* into *ext.* This method has its drawbacks; but, as the book is intended, primarily, to assist the student in the revision of his work, it is hoped that no one who has already been over the ground, with the aid of a dissecting manual, will have any difficulty in understanding the statement of fact, though the fact is stated in a compressed form.

The book is meant to be used as a companion to a dissecting manual, for revision of work while the dissection of a "part" is in progress; and the various structures are dealt with under their systems, in order that the dissector shall not lose sight of the fact that each structure may be found in other regions besides that which, at the moment, is engaging his attention. But the book may be used also for revision after the dissection of the body is completed; and, as the "regional" method of study should never be abandoned, there has been included, in small type, a full account of the relations in the more important "regions," such as the *Triangle of the Neck*, etc.

It is hoped that the usefulness of the book will be increased by the accounts given of the relations of the structures in the "boundary" regions, such as the *Inguinal Ligament*, the relations of the joints, and the relationship of articular capsules to the epiphyseal lines of

COMPANION TO MANUAL OF PRACTICAL ANATOMY

OSTEOLOGY

THE mammalian skeleton consists of : (1) an **exo-skeleton**, comprising hair, feathers, scales, armour plates, nails, teeth, etc. ; (2) an **endo-skeleton**, comprising bones with their cartilages and ligaments ; (3) a **splanchnic skeleton**, which may be included in endo-skeleton, and comprises the cartilages of larynx, trachea and bronchi, and the os cordis and os penis of certain mammals.

The endo-skeleton forms the framework of the body, supports the softer structures, muscles, etc., which surround it, and protects organs within the cavities of the body. It is divided into an **axial skeleton**, belonging to head, neck and trunk, and an **appendicular skeleton**, belonging to the extremities or limbs.

The bones and the costal cartilages of the endo-skeleton are dealt with under Osteology. Bones provide attachments and support for muscles and their tendons, ligaments, fibrous membranes and fascia. They articulate with each other to form joints, and are the passive levers in the movements at joints, and by means of them precision is given to movements. They are protective agents to viscera, vessels, central, and parts of peripheral, nervous system ; and, in virtue of their marrow, they are blood-forming organs. The surfaces of bones which touch one another, in an articulation, are coated with permanent **articular cartilage**. In the preparation of dried specimens, used in reading, this cartilage has been removed.

Bones are classified as : (1) **Long bones**, each possessing a shaft or body and two extremities, *e.g.* femur. Metacarpals, metatarsals and phalanges are **miniature long bones**. (2) **Short bones**, *e.g.* carpal and tarsal bones. Short bones include **sesamoid bones**; these are bones developed in the substance of tendons. (3) **Flat bones**, *e.g.* scapula, parietal bone of skull, ribs. (4) **Irregular bones**, *e.g.* vertebrae. **Pneumatic bones** are certain bones of the skull, *e.g.* maxilla, containing air-spaces or sinuses which communicate directly or indirectly with the nasal cavity.

The osseous tissue on the surface of a bone is dense and hard, and is called **compact bone**. The tissue in the interior contains numerous spaces, like a sponge, and it is called **spongy** or cancellous **bone**. The spaces are filled with **red marrow**. Short bones and the bulky parts of irregular bones consist of a shell of compact tissue surrounding spongy tissue. Flat bones and the thinner parts of irregular bones consist of two plates or **tables** of compact tissue, separated by a thin layer of spongy tissue. In flat skull bones the outer table is thick : the inner table is thin, very dense and brittle, and is sometimes called the **vitreous table**; and the spongy tissue between the tables is called the **diploë**. Diploë does not appear till after 5th or 6th year.

Extremities of long bones are expanded in order : (1) to provide a larger surface for articulation and so minimise risk of disarticulation, and to facilitate accuracy of movement; (2) to diffuse shocks received at the joint; (3) to provide a larger area for muscular attachments. They consist of a thin shell of compact bone surrounding spongy bone, in which the tissue is arranged in planes adapted to withstand stress and strain. *Shaft* of a long bone is a hollow cylinder, consisting of a thick wall of compact tissue, lined with some wide-spaced spongy tissue, and enclosing a **medullary cavity**, which is filled with **yellow marrow**. The shaft is always curved, and usually in more than one plane. This adds to its strength and resistance, which are further ensured by the greater thickness of the compact tissue on the concave sides of the curves. The presence of a cavity not only makes the bone lighter, but it adds to the strength and stability.

Bones are covered with a vascular fibrous membrane called **periosteum**. Vessels from the periosteum enter the bone through small foramina on the surface. A larger artery,

which enters the shaft of a long bone, through the **nutrient foramen**, to reach the medullary cavity, is called the **nutrient artery**. Articular cartilage has no membranous covering, but other cartilages, e.g. costal cartilages, have a similar vascular covering, called **perichondrium**. Medullary cavity of a long bone and the spaces in spongy bone are lined with membrane called **endosteum**.

Bones are developed from mesoderm. A condensation of mesodermal tissue takes place to form a **membranous "bone."** In some regions, e.g. vault of cranium, ossification occurs in this membrane. In most situations, chondrification of the membrane bone takes place and a **cartilage "bone"** is formed. One or more **centres of ossification** appear in the cartilage, and it is converted into bone proper. Centres which first appear are called **primary centres**. They appear usually before birth. The part of a bone formed from a primary centre is called the **diaphysis**. In the case of a long bone this is the shaft. **Secondary or epiphyseal centres** appear usually after birth. Parts of bones formed from secondary centres are called **epiphyses**. The unossified plate of cartilage between an epiphysis and the diaphysis is called the **epiphyseal cartilage**. It unites the epiphysis and diaphysis, and the union is called an **epiphyseal synchondrosis**. The position of the periphery of the epiphyseal cartilage, on the surface of the bone, is called the **epiphyseal line**. Ossification and growth take place continually at the surfaces of the epiphyseal cartilage, until the cartilage disappears and the epiphysis joins the diaphysis, when growth, in the direction at right angles to the surface of cartilage, ceases. Ossification never spreads into the articular cartilage. Osseous tissue formed in cartilage is all destroyed during the process of growth of the bone, and is replaced by bone formed in the deeper layers of the periosteum. In a long bone, increase in length takes place by proliferation of cells of epiphyseal cartilage, followed by the preliminary ossification; increase in girth takes place by deposition of bone under the periosteum. In a long bone, the epiphysis whose centre appears last is the first to join the diaphysis, except in case of fibula. The nutrient artery is directed towards the epiphysis which joins last. In the case of long bones with only one epiphysis, e.g. clavicle, the artery is directed towards the end which has no epiphysis.

When an epiphysis has more than one centre, e.g.

proximal end of humerus, these centres coalesce before epiphysis joins diaphysis.

Axial Skeleton

Vertebral column	Skull, including mandible
Ribs and costal cartilages	Hyoid bone
Sternum	Auditory ossicles

Appendicular Skeleton

Upper Limb	Lower Limb
Shoulder girdle { Clavicle	Pelvic girdle Hip bone
Arm { Scapula	Thigh { Femur
Forearm { Humerus	Leg { (Patella)
Wrist { Radius	Foot { Tibia
Palm { Ulna	{ Fibula
{ 8 Carpal bones	{ 7 Tarsal bones
{ 5 Metacarpal	{ 5 Metatarsal bones
{ bones	{ Great toe, 2 phal-
{ Thumb, 2 phal-	{ anges
{ Fingers, 3 phal-	{ Other toes, 3 phal-
{ anges each	{ anges each
Sesamoid bones	Sesamoid bones

Definitions

Alveolus, a deep, narrow pit.

Antrum, a cavity.

Condyle, a smooth, rounded articular eminence.

Distal, applied to limbs, means further away from root of limb.

External, further away from centre of a cavity or an organ.

Fossa, a broad depression, usually shallow.

Fovea, a small shallow depression.

Hamulus, a hook-shaped process.

Hiatus, a slit, or a gap.

Incisura, a notch.

Internal, nearer the centre of a cavity or an organ.

Lamina, a thin plate or sheet.

Lateral, further away from median plane.

Meatus, a short canal.

Medial, nearer median plane.

Median plane is the antero-posterior or dorso-ventral plane, dividing the body into a right and a left half.

Planum, a flat surface.

Processus or process, any kind of projection.

Proximal, applied to limbs, means nearer root of limb.

Sinus (1), a cavity in a bone.

(2), a venous blood channel without muscular walls.

(3), a venous blood space in an organ.

(4), a cavity within a viscus.

(5), a narrow space lined with serous or mucous membrane.

Spina or Spine, a sharp, pointed process.

Sulcus, a groove or furrow.

Trochlea, a pulley or pulley shaped surface.

Tuber, tuberculum }

Tubercle, tuberosity | a rounded eminence, usually rough.

Volar Surface applied to the surface of forearm and hand which looks forwards when arm hangs down with thumb directed laterally.

COLUMNA VERTEBRALIS

Vertebral column or spine consists of 33 vertebrae, grouped according to regions:—

Movable or true vertebræ, 7 cervical, 12 thoracic, 5 lumbar.

Fixed or false, 5 sacral, fused in adult to form **sacrum**; 4, 3 to 5 coccygeal, fused to form **coccyx**.

Common characters of vertebrae are seen best in mid-thoracic region.

Parts of a vertebra. 1 **Corpus Body** is the bulk, anterior part and varies in size and shape in different regions. Superior and inferior surfaces, slightly concave and attached to intervertebral fibro cartilage. Ventral surface, convex from side to side; dorsal surface, slightly concave from side to side.

2 **Radix arcus vertebræ** (pedicle), a horizontal bar projecting dorsally, on each side, from upper part of posterior aspect of body. Upper and lower borders are depressed, forming

3 **incisuræ vertebrales, superior and inferior vertebral notches**, of which the inferior is the wider. 4 **Laminæ** are

two broad, flat, sloping plates, joined to each other at median plane, and to roots of vertebral arch pedicles laterally. Their borders and internal surface are rough for attachments of ligamenta flava. Roots of arch and laminae together form 5 **arcus vertebræ**. 6 **Foramen vertebrale** bounded by vertebral arch and posterior aspect of body.

7 **Processus spinosus spine** projects dorsally from junction of laminae. (8) **Processus transversus** projects laterally from

junction of root and lamina. (9) **Processus articulares**, superior and inferior, project upwards and downwards from junction of root and lamina, and have smooth surfaces for articulation with articular processes of contiguous vertebrae; superior pair are on a more anterior plane than the inferior.

When vertebrae are placed together the vertebral foramina form **canalis vertebralis** (spinal or neural canal), for lodgment and protection of spinal medulla (spinal cord) and its membranes; and vertebral notches, assisted by articular processes, bodies and fibro-cartilages, form a series of **foramina intervertebralia**, for transmission of spinal nerves and vessels.

CERVICAL VERTEBRÆ

Special Character. — *Transverse process encloses a foramen called Foramen Transversarium.*

Typical Cervical Vertebra. — **Body**: small, elongated transversely. **Roots of vertebral arch** (pedicles): short and rounded. **Laminæ**: long, narrow, sloping. **Vertebral foramen**: large; triangular or semilunar. **Spine**: short, bifid. **Transverse process**: short, encloses foramen; is bifid, ending in two tubercles anterior and posterior. Articulating surfaces of articular processes are nearly circular.

Upper surface of **body** is concave from side to side, convex dorso-ventrally; rounded off anteriorly, raised up at sides. Lower surface is correspondingly concavo-convex. Ventral surface is slightly elevated in the middle, slightly hollowed out on each side. Dorsal surface is flat. Lateral aspect is fused with transverse process and root of arch, and helps to bound transverse foramen.

Root of vertebral arch springs from dorso-lateral aspect of body, is directed dorsally and laterally, and its **vertebral notches** are nearly equal in depth. **Vertebral foramen** is larger than in thoracic or lumbar regions. **Spine** is compressed vertically, and is directed dorsally and downwards.

Transverse process projects laterally, and slightly ventrally and downwards. Consists of two parts: (1) dorsal part—the true transverse process—springs from vertebral arch; (2) ventral part—the homologue of a rib—is attached to side of body. The two parts are united laterally by **costo-transverse lamella**, and enclose **foramen transversarium**. Bifid free end terminates in **anterior** and **posterior tubercles**. These are separated by grooved upper surface of **costo-transverse lamella**, over which the anterior branch

of spinal nerve passes. Anterior tubercle in 6th vertebra is sometimes enlarged, and is called **carotid tubercle** because the common carotid artery can be compressed against it.

Foramen transversarium is bounded by the parts of the transverse process, and by root of arch and side of body. In upper 6 vertebrae it transmits vertebral artery and veins, and sympathetic plexus from inferior cervical ganglion.

Articular processes assist bodies in supporting weight of head. Articulating surfaces of superior pair look upwards and dorsally; of inferior pair, downwards and ventrally.

Typical cervical vertebrae—3rd, 4th, 5th, 6th—of any one skeleton can be distinguished from one another. Costo transverse lamella in 3 and 4 is oblique. It is more oblique in 3 than in 4, and vertical depth of side of body is greater in 3. The lamella is horizontal in 5 and 6, and 6 often has an enlarged "carotid tubercle."

Special Cervical Vertebrae. **First cervical vertebra** or **Atlas** has no body and no spine. Consists of 2 lateral masses united by an anterior and a posterior arch. Anterior arch has circular facet—**fovea dentis**—on posterior surface, for articulation with dens, odontoid process of 2nd vertebra; and a small **anterior tubercle** on anterior surface. Posterior arch is much longer than anterior. It has a groove for vertebral art. and 1st cervical nerve on its upper surface, near lateral mass; and a small **posterior tubercle** on its posterior surface, in median plane. Upper surface of lateral mass is elongated and concave, and articulates with occipital condyle; lower surface, nearly circular, articulates with upper facet of 2nd vertebra; medial surface presents a tubercle for attachment of transverse ligament. **Transverse process** projects from lateral side of mass. It is large, not bifid, and may be felt in space behind mandible, below the ear.

Anterior ends of **lateral masses** are closer together than the posterior. **Superior articular fovea**, on upper surface of mass, is oval, looks upwards and medially, and is sometimes partially subdivided by notches at the sides.

Inferior articular surface is slightly concave and looks downwards and medially. **Recurvatus capitis anterior, anticus minor** arise from ant. surface of mass; and accessory ligament of the joint between it and 2nd cervical is attached to postero-medial aspect of mass. Transverse ligament crosses the ring and divides it into small anterior compartment for dens, odontoid process, and larger posterior compartment for spinal medulla and its membranes.

Transverse process is obliquely compressed and its tubercles

are fused into one mass. Rectus lateralis, obliquus superior and inferior, levator scapulæ and splenius cervicis are attached to it.

Anterior arch is connected with anterior and medial aspects of masses. Anterior atlanto-occipital membrane is attached to its upper border, and ant. longitudinal lig. and longus colli to its **anterior tubercle**. **Posterior arch** inclines upwards. It is connected with dorsal aspect of mass and with posterior root of transverse process. Posterior atlanto-occipital membrane is attached to upper border, and lig. flava to lower border. Groove on upper surface is overhung by tubercle on back of mass. This tubercle is sometimes sufficiently developed to convert groove into a canal. **Posterior tubercle**, at median plane, represents spinous process, and gives origin to recti posteriores minores.

Second Cervical Vertebra or **Epistropheus** (Axis).—Distinguished by a tooth-like projection from upper surface called **Dens** or **odontoid process**, which presents a facet on its anterior surface for anterior arch of atlas, and a smooth shallow groove on posterior surface, in contact with transverse ligament of atlas. **Spine** is stout, broad, bifid, and can be felt about 2 inches below external occipital protuberance. **Transverse process** is small and not bifid.

Body has a triangular elevation on anterior surface, whose base forms a downward projecting lip. **Odontoid process** represents body of atlas. To its blunted apex the lig. apicis dentis and lig. alaria are attached (suspensory and check ligaments). **Roots of arch** are deeply grooved below; hidden by superior articular surfaces above. **Laminæ** are thick and prismatic. **Spine** is the broadest of cervical series, and is deeply grooved on under surface.

Superior articular processes lie on roots of arch and anterior roots of transverse processes, and slightly on body. Weight of head is transmitted through them to vertebral column. They are nearly circular, slightly convex; look upwards and a little laterally; are grooved inferiorly by foramina transversaria. Behind each is a groove for 2nd cervical nerve. (1st and 2nd cervical nerves, unlike others, are posterior to articular surfaces.) **Inferior articular processes** resemble others of cervical region. **Transverse process** is not bifid, is the smallest in the series, and is turned downwards and dorsally. Its foramen is directed upwards and laterally.

Seventh cervical vertebra is called **vertebra prominens**, because its **spine** is longer than that of any other cervical vertebra, and forms a projection at root of back of neck.

End of **spine** is broad and not bifid. **Transverse process** is large and broad; its anterior tubercle is small or absent; its costal

element may form a separate **cervical rib**. **Foramen transversarium** is small and transmits a vein sometimes.

THORACIC VERTEBRÆ

Special Characters. *Facets on sides of bodies for heads of ribs, and facets on most transverse processes for tubercles of ribs.* Each thoracic vertebra articulates with rib with which it is in numerical correspondence; and bodies of upper 8 or 9 articulate each with rib below, as well.

Typical Thoracic Vertebra.—**Body** is heart-shaped, and its dorsal surface has greater vertical depth than ventral, in conformity with curve of column. **Foveæ costales, superior and inferior**, are demi-facets on upper and lower margins of posterior part of side of body. **Roots of vertebral arch pedicles** are short. **Laminæ** are broad, flat and imbricated, *i.e.* each overlaps lamina below. **Vertebral foramen** is nearly circular, and smaller than in cervical or lumbar vertebra. **Spine** is long, sloping and slender. **Transverse process** is thick. Its free end is expanded and bears on anterior surface the **fovea costalis transversalis** a facet for articulation with tubercle of rib of corresponding number. **Articular surfaces of articular processes** are nearly flat; those on superior pair are directed mainly dorsally, on inferior pair, mainly ventrally.

Upper and lower surfaces of **body** are nearly flat. Ventral surface is very convex from side to side, slightly concave from above downwards. Dorsal surface is concave from side to side, and flat from above downwards. In upper and lower members the shape of body resembles that of cervical and lumbar, respectively. **Superior costal fovea** is larger than inferior, and, with inferior fovea of vertebra above and intervening fibro cartilage, it forms articular cavity for head of rib.

Root of arch is directed dorsally and flattened from side to side; is attached close to upper margin of body, and, therefore, upper **vertebral notch** is shallow, lower is deep. **Spine** tapers to a tuberculated free extremity; is triangular on section; very oblique (almost vertical) in middle of series, shorter and much less oblique in upper and lower members. **Transverse processes** are directed laterally, dorsally and a little upwards. **Superior articular processes** look slightly upwards and laterally as well as dorsally; inferior pair look in opposite direction, and are partly fused with laminae.

Special Thoracic Vertebrae.—**First**: body resembles that of 7th cervical in outline, and has a whole facet and a half facet on

each side. Whole facet is for 1st rib, which articulates with only one vertebra. Spine is nearly horizontal, easily seen and felt, even more prominent than 7th cervical.

Ninth may conform to type (in which case the costal fovea on 10th is incomplete); or it may lack inferior fovea.

Tenth, eleventh and twelfth have each only one facet on side of body, and it encroaches on root of arch. 10th is recognised from the other two by facet on its transverse process. 11th is distinguished from 10th by absence of this facet, and from 12th by inferior articular processes, which look in typical direction. 12th has its transverse process broken up into *superior*, *inferior* and *lateral tubercles*, homologous with mamillary process, and with accessory and small part of transverse process of lumbar vertebra, respectively; and its inferior articular surfaces are convex, and directed laterally and ventrally, like those of a lumbar vertebra.

LUMBAR VERTEBRÆ

Distinguished by large size, by absence of foramen in transverse process, and absence of costal fovea.

Common Characters.—**Body** is large and kidney-shaped. **Roots of vertebral arch** (pedicles) are short and stout. **Laminae** are thick, and are separated from those below by an interval near median plane, widest between 4th and 5th. **Vertebral foramen** is large and triangular. **Spine** is almost horizontal; large, broad and hatchet-shaped, with thickened posterior border. **Transverse process** is long, slender, spatula-shaped. **Articular processes** are large; superior pair are concave and look mainly medially, inferior pair convex and look laterally.

Upper and lower surfaces of **body** are nearly flat; ventral surface is convex from side to side, concave from above downwards; dorsal surface is slightly concave in both directions. **Roots of arch** are directed dorsally from near upper part of body; therefore, superior **vertebral notch** is shallow, inferior is deep. **Laminae** are broad from above downwards, and are nearly vertical.

Transverse processes are homologous with ribs, and project laterally and dorsally; on back of base of each is a small tubercle, called **accessory process**. **Superior articular processes** look slightly dorsally as well as medially, and embrace inf. processes of vertebra above. On dorsal edge of each there is rounded tubercle, called **mamillary process**. **Inf. artic. processes** look ventrally as well as laterally. They are supported on lower and lateral parts of laminae, and are closer together than superior pair.

Special Characters.—Dorsal surface of body of **first** is often deeper than ventral; in **second**, they are of equal depth. Transverse process of **third** is usually the longest, and encroaches on root of arch; and ventral surface of body is deeper than dorsal. Ventral surface of body of **fourth** is deeper than dorsal; transverse process encroaches on root of arch and may reach body; inferior articular processes are as wide apart as the superior.

Fifth lumbar vertebra is the largest of all vertebræ. Ventral surface of **body** is much deeper than dorsal. **Roots of arch** run laterally and dorsally. **Transverse process** is short, stout and pyramidal, its base encroaching well on to body. **Spine** is short, and rounded at free end. **Superior articular processes** look more dorsally and less medially than in other L. vertebræ; **inf. artic. processes** are further apart than superior, and look more ventrally and less laterally than in other lumbar vertebræ.

Muscles and Ligaments attached to Vertebræ

Bodies—

Longus colli. 2nd-7th C., 1st-3rd TH.

Psoas minor. 12th TH., 1st L.

Psoas major. 12th TH., 1st-5th L.

Lig. longitudinalia, anterior and posterior. 2nd C. to sacrum.

Capsule articulares of small joints at sides of cervical bodies.

Capsule articulares and lig. radiata of costo-vertebral joints.
1st-12th TH.

Medial lumbo costal arch. 2nd L.

Laminæ—

Ligamenta flava. ALL.

Lig. costo-transversaria post. 1st-11th TH.

Rotatores. 1st-11th TH.

Articular Processes—

Longissimus capitis. 4th-7th C.

Semispinalis

.. cervicis. ..

Multifidus 1st-5th L.

Capsule articulares. ALL.

Transverse Processes

Rectus capitis lateralis. 1st C.

Obliquus capitis superior. 1st C.

.. .. inferior ..

Levator scapulae. 1st-4th C.

Interspinales. 1st C. 5th L.

Splenius cervicis. 2nd-4th C.

Splenius medius. 2nd-6th C.

Longissimus cervicis. 2nd-6th C., 1st-6th TH.

Transverse Processes (*contd.*)—

- Longus capitis. 3rd-6th C.
 Longus colli. " "
 Scalenus anterior. " "
 Ilio-costalis cervicis. 4th-6th C.
 Scalenus posterior. " "
 Levatores costarum. 7th C., 1st-11th TH.
 Longissimus capitis. 1st-6th TH.
 Semispinalis capitis. " "
 Semispinalis cervicis. " "
 Multifidus. 1st-12th TH.
 Longissimus dorsi. 1st-12th TH., 1st-5th L.
 Rotatores. 2nd-12th TH.
 Semispinalis dorsi. 7th-12th TH.
 Psoas major. 1st-5th L.
 Quadratus lumborum. 1st-5th L.
 Inter-transverse ligaments. ALL.
 Lumbo-costal ligament. 12th TH., 1st L.
 " " arches. 1st L.
 Sibson's fascia. 7th C.
 Capsule articulares of costo-transverse joints. 1st-10th TH.
 Lig. tuberculi costæ. 1st-10th TH.
 Lig. colli costæ. 1st-11th TH.
 Lig. costo-transversaria ant. and post. 1st-11th TH.
 Middle and anterior layers of lumbo-dorsal fascia. 1st-5th L.
 Ilio-lumbar ligament. 5th L.
 Lumbo-sacral ligament. 5th L.

Spines—

- Obliquus capitis inferior. 2nd C.
 Rectus capitis posterior major. 2nd C.
 Semispinalis cervicis. 2nd-5th C.
 Spinalis cervicis. 2nd-4th C., 7th C., 1st and 2nd TH.
 Interspinales. 2nd C.-5th L.
 Multifidus. 2nd C.-5th L.
 Semispinalis dorsi. 6th and 7th C., 1st-4th TH.
 Rhomboideus minor. 7th C., 1st TH.
 Serratus posterior superior. 7th C., 1st-3rd TH.
 Splenius. 7th C., 1st-5th TH.
 Trapezius. 7th C., 1st-12th TH.
 Rhomboideus major. 2nd-5th TH.
 Spinalis dorsi. 4th-8th TH., 11th and 12th TH., 1st and 2nd L.
 Sacrospinalis. 1st-5th L., 1st-3rd S.
 Lig. nuchæ. 2nd-7th C.
 Interspinous and supraspinous ligs. All TH. and 1
 Lumbo-dorsal fascia. 1. TH. S.

OS SACRUM

Sacrum is roughly triangular in shape, possessing *base* or upper surface, *apex* or lower end, *dorsal*, *pelvic* and two *lateral surfaces*. Divided, on both dorsal and ventral surfaces, by two series of foramina into a *median portion*, composed of most of parts of five fused vertebrae, and two *lateral parts* or *masses*, composed of fused costal elements and transverse processes.

Basis is directed upwards and ventrally. Ventral and central part is the upper surface of body of 1st sacral vertebra. Its projecting anterior margin is called the **promontory**. Dorsal to body, is the large, sloping, triangular **vertebral foramen**, leading into **canalis sacralis**, and, on each side of it, the upstanding **superior articular process** looks dorsally and slightly medially. Spreading laterally from body is the fan shaped *ala* of sacrum, or base of lateral mass.

Apex is the oval lower surface of body of small 5th sacral vertebra.

Pelvic Surface. Concave; directed downwards and ventrally. Median part is composed of bodies. Lines of fusion are indicated by 4 *lineae transversae*, which end laterally at sides of **anterior sacral foramina**. From the foramina, shallow grooves extend laterally.

Dorsal Surface. Convex and irregular. Presents 4 **posterior sacral foramina** on each side. **Crista sacralis media** is the interrupted ridge in median plane; **sacral groove** is formed by the bone between it and the foramina. **Crista sacralis articularis** is the series of tubercles at lateral edge of groove, medial to the foramina. **Hiatus sacralis** is the gap, at lower end, leading out of sacral canal. **Sacral cornua** are the 2 processes projecting downwards, one from each side of hiatus. **Crista sacralis lateralis** is the series of tubercles lateral to the foramina.

Lateral Surface. Upper part is broad. Its ventral portion is occupied by ear-shaped **auricular surface**, for articulation with ilium; and dorsal portion presents a rough irregular depression for interosseous sacro iliac ligaments. Part corresponding to lowest 2 vertebrae is narrow, and at **inferior lateral angle** it turns sharply medially towards body of 5th.

Canalis sacralis is wide and triangular above, small and

flattened below; and from it 4 pairs of **foramina intervertebralia** pass laterally, and divide into anterior and posterior sacral foramina.

Female sacrum is relatively broader than male, and is less uniformly curved, being usually flat above and abruptly curved below.

Posterior wall of **sacral canal** is formed by membrane where laminae of 5th sacral vertebrae are absent. Its **Contents** are: roots of sacral and coccygeal nerves, filum terminale, and their sheaths; tube of dura mater, pervious to 3rd piece of sacrum; lateral sacral vessels; spinal plexus of veins. **Hiatus sacralis** transmits 5th sacral and coccygeal nerves and filum terminale.

Anterior sacral foramina decrease in size from above downwards. Each transmits— anterior branch (ant. primary division) of a sacral nerve and branches of lateral sacral vessels. The nerves, passing laterally, lie in the grooves leading away from the foramina. **Posterior sacral foramina** also decrease from above downwards. They lie directly opposite anterior foramina, and are smaller. They transmit posterior branches (post primary divisions) of sacral nerves and emerging branches of lateral sacral vessels.

Ala of sacrum is slightly concavo-convex and slopes downwards and ventrally. Its convex lateral margin ends dorsally in a tubercle the end of the **transverse process**. This is separated by a deep notch from sup. artic. process, which is fused with representative of root of **vertebral arch**. The tubercles on median sacral crest represent **spines** of upper 4 sacral vertebrae. Sacral groove is formed by fused **laminae**. Laminae of 5th vertebra do not meet and spine is absent, and resulting gap is hiatus sacralis. Tubercles on articular sacral crest represent **articular processes**. They lie in line with intervals between spines. Articular processes of 5th project downwards as sacral cornua. Each tubercle of lateral sacral crest represents parts of tips of two **transverse processes**.

First coccygeal vertebra may be fused to sacrum; less often the 5th lumbar is partially or entirely fused, or 1st sacral may be partially free from 2nd.

Attachments.— Intervertebral fibro-cartilage, ant. and post. longitudinal ligs. to body of 1st piece. Capsular ligament to sup. artic. process. Lig. flavum and supraspinous lig. to dorsal margin of **vertebral foramen**. Lumbo-sacral lig. and iliacus to ala. Ant. sacro-iliac lig. to ventral margin of **auricular surface**. Piriformis from ridges between ant. foramina and from adjoining pelvic surface of **lateral mass**. Coccygeus to surface below and lateral to 4th foramen. Sacro-spinalis, multifidus and glutaeus maximus from **dorsal surface**. Long and short posterior sacro-iliac ligs. and lig. sacro-

tuberosum (great sacro-sciatic) to tubercles of **lateral crest** (transverse tubercles). Interosseous lig. to rough area, dorsal to auricular surface. Gluteus maximus, lig. sacro-tuberosum, lig. sacro-spinosum (small sacro-sciatic) and coccygeus are attached, in that order from behind forwards, to narrow lower part of **lateral surface**. Inter-articular lig. unites sacral to coccygeal **cornu** and converts the interval into 5th inter-vertebral foramen, for exit of 5th sacral nerve. Lateral sacro-coccygeal lig. connects inf. **lateral angle** with trans. process of coccyx, and bounds 5th sacral foramen for passage forwards of 5th s. nerve; lig. may ossify. Fibro-cartilage and ant. and post. sacro-coccygeal lig. to body of 5th.

OS COCCYGIS—COCCYX

Coccyx is triangular in shape, with apex downwards. It has *base, apex, dorsal and pelvic surfaces*, and *lateral borders*. It is formed almost entirely of rudimentary bodies of 4 vertebrae, which tend to fuse.

First piece is largest. Oval concave facet on **body** forms base of coccyx and articulates with body of 5th sacral. **Transverse process** stands out from side of body and is united to inf. lateral angle of sacrum by lateral sacro-coccygeal lig. **Cornua coccygea** represent articular processes. They project upwards from dorsum of body, and are connected by ligaments to sacral cornua. **Second piece** has small body and rudiments of roots of vertebral arch and transverse processes. Other pieces are merely small nodules.

Attachments—Gluteus maximus and filum terminale are attached to **dorsum** of coccyx; coccygei levatores ant. lig. sacro-tuberosum and sacro-spinosum (sacro-sciatic) to its **sides**; ext. sphincter to its **tip**.

Glomus coccygeum (coccygeal body) and ganglion impar lie on its **pelvic surface**.

VERTEBRAL COLUMN AS A WHOLE

28 inches long in male, nearly 24 in female. Superimposed bodies form column for support of trunk and head; vertebral foramina provide a canal for spinal medulla and its membranes; spinous and transverse processes form 3 interrupted ridges bounding 2 **vertebral grooves**, of which the laminae form the floors; they are occupied by muscles which move the column.

Viewed from the side, the bodies form 4 curvatures: cervical and lumbar, convex anteriorly; thoracic and sacro-

coccygeal, concave anteriorly. **Sacro-vertebral angle** is the projection where lumbar curve passes into sacro-coccygeal, at lumbo-sacral joint. Thoracic and sacro-coccygeal curves are present in fetus and are called **primary**. They are due to shape of bodies. Cervical curve results from elevation and extension of head in infancy; lumbar, from assumption of erect attitude, when child begins to walk. These two are called **secondary** or **compensatory**. They are due chiefly to shape of fibro-cartilages. Cervical curve can always be undone by flexing neck; lumbar curve cannot be undone in adults. Lumbar curve is more pronounced in female than male. Curves of spines are not repetitions of these, owing to differences in length and obliquity. In mid-thoracic region, the tips of spines are considerably below level of bodies of corresponding vertebrae. Intervertebral foramina increase in size down to 5th lumbar. In sacrum, they diminish from above downwards. In cervical region, the transverse processes are ventral to articular processes, and in line with intervertebral foramina; in thoracic region, they are dorsal to both; in lumbar region, they are dorsal to foramina, but rather ventral to articular processes.

Viewed from the Front.—Bodies increase in breadth from 2 C. to 1 TH. ; diminish from 1 TH. to 4 TH. Increase from 4 TH. to 1st sacral, below which there is rapid reduction. Sometimes there is slight lateral curvature in thoracic region, convex usually to right, owing either to greater use of right arm or to pressure of descending aorta. Above and below, there are slight compensatory curves in opposite direction. Transverse processes of atlas are wide and outstanding; those of next 5 are short and nearly equal in length; those of 7th are long, nearly as long as 1st thoracic. They gradually diminish down to 12th thoracic, where they are represented by tubercles. They are outstanding again in lumbar region, third being longest usually. Column is widest at base of sacrum. Below this diminution is gradual at first, abruptly increased at 3rd piece of sacrum, and greatly accentuated opposite 5th.

OSSIFICATION OF VERTEBRÆ

Typical Vertebra.—3 primary centres. 1 for *body* appears first in lower thoracic region, about 10th week. Process spreads up and down, and by 5th month centres have appeared

In all bodies, except coccygeal. 2 for *vertebral arch* appear at bases of superior articular processes, first in upper cervical region, about 7th week. Process extends rapidly downwards. From these two centres the vertebral arch, all processes, and the lateral parts of body are ossified.

Lateral parts of body join central part about 3rd or 4th year. Till then they are separated by plate of cartilage—**neuro-central synchondrosis**. In thoracic region, the ribs articulate with part of body ossified from centre for vertebral arch. Line of synchondrosis is antero-posterior in cervical region, oblique in thoracic, nearly transverse in lumbar region. Ossification of laminae is completed after birth—first in lumbar region. Extends up and down. Complete in cervical at 15th month, in sacrum from 7th to 10th year. After union of laminae, ossification extends into spines.

Five secondary or epiphyseal centres appear at puberty, and epiphyses formed from them have joined rest of bone about 25th year. 1 for tip of *spine*, except in cervical region. 1 at end of each *transverse process*. 1 on upper and 1 on lower surface of *body*; these two form epiphyseal rings.

In 6th and 7th cervical, a separate centre may appear in anterior root of transverse process, and may persist as cervical rib. In lumbar region, mamillary processes have separate centres; vertebral arch of 5th may have 2 centres on each side; transverse process of 1st l. sometimes has independent costal centre that may persist as lumbar rib.

Atlas.—2 centres for *vertebral arch*, *i.e.* for lateral masses, posterior arch, transverse processes; appear 7th fetal week, unite dorsally after 3rd year. 1 or 2 centres for **anterior arch**, which unites with lateral masses at 6th to 8th year. **Transverse processes** are completed by epiphyses about 18th year.

Epistropheus (Axis).—2 centres for *arch* and *processes*, about 7th week. 1 or 2 for **lower part of body**, at 5th fetal month. 2 (which coalesce) for **upper part of body**, including base of dens (odontoid process), a little later. *At birth*, epistropheus consists of 4 pieces, which unite between 3rd and 6th years. 1 epiphyseal centre for tip of *dens (odontoid process)* appears 3rd to 5th year, unites 8th to 12th year. Annular epiphysis appears on *lower surface of body* at puberty.

Sacrum.—1 centre for each *body*, 2 for each *vertebral arch*. **Costal elements** of upper three have each a centre which appears 6th to 8th month. These unite with arches between 2nd and 5th years. 2 epiphyseal plates for each *body*. 1 epiphysis for auricular surface, 1 for narrow edge below it. Fusion of bodies takes place,

from below upwards, between 18 and 20 years, and is preceded by fusion of segments of lateral mass.

Coccyx, *cartilaginous at birth*. Centre for first piece appears between 1st and 4th year; for last piece, about puberty. Fusion begins below, and is very variable.

STERNUM OR BREAST BONE

Sternum.—Lies in anterior wall of thorax. Supports clavicles and upper 7 pairs of costal arches. Consists of **manubrium**, above; **body**, formed by fusion of 4 segments, in the middle; **xiphoid process**, below.

Manubrium is the broadest part. Flattened; triangular, with truncated apex inferiorly. **Anterior surface**, rough, slightly elevated superiorly and in median plane; **posterior surface**, smooth, concave. **Upper border**, thick; presents 3 notches:—*Incisura jugularis*, in middle, forms bottom of suprasternal notch; *incisura claviculares*, laterally, articulate with clavicles. **Lateral border**: upper part prominent and hollowed out for 1st costal cartilage; lower part slopes medially and ends below as facet for upper part of 2nd costal cartilage. **Lower border** or apex: thick, but shorter than upper border; articulates with body by fibro-cartilaginous synchondrosis—*synchondrosis sternalis*.

Corpus (Body, Gladiolus).—Narrower than manubrium, but about twice as long. Increases in width down to junction of 3rd and 4th segments, and then rapidly diminishes. **Planum sternale (anterior surface)** is slightly convex from above downwards; subcutaneous in median plane, crossed by 3 faintly marked ridges which indicate positions of fusion of 4 segments. **Posterior surface**: smoother, concave. **Lateral border**: thick; opposite the anterior ridges are *incisura costales* for 3rd, 4th, 5th costal cartilages, while notch for 6th is at lower part of 4th segment. **Upper end** is united to manubrium and has facets laterally for 2nd costal cartilages. Manubrium and body form a projecting angle at their junction, called *angulus sterni*, and felt subcutaneously as transverse elevation—the landmark for adjoining 2nd rib and cartilage. **Lower end** articulates with xiphoid process and with 7th costal cartilages.

Processus Xiphoideus (Ensiform Cartilage).—Varies in size and shape. Cartilaginous, with bony core in upper part enlarging with age. Thinner than body of sternum, and its

posterior surface being in line with that of body, its anterior surface is on deeper plane than that of body, and forms floor of *infrasternal depression* or pit of stomach. **Upper end** articulates with body of sternum and with 7th costal cartilages. **Anterior and posterior surfaces, lateral borders and lower end** give attachment to muscles and ligaments.

Upper border of manubrium is at level of fibro-cartilage between 2nd and 3rd thoracic vertebrae; sternal angle, at level of upper part of 5th TH. vertebra; upper end of xiphoid, at level of fibro-cartilage between 9th and 10th.

Attachments.—Articular disc of sterno-clavicular joint to junction of manubrium and 1st costal cartilage; it intervenes between clavicle and clavicular notch. Capsular ligament to and beyond margins of clavicular notch. Interclavicular lig. to jugular notch. Sternal head of sterno-mastoid to upper part of anterior surface of manubrium; sterno-hyoid and sterno-thyreoid to upper part of posterior surface. Pectoralis major and ant. sterno-chondral lig. to ant. surface of manubrium and body, and post. sterno-chondral lig. to their post. surfaces. Transversus thoracis to lower part of post. surface of body. Interarticular lig. (when present) to costal notches. Ant. intercostal membranes to margins of manubrium and body between notches. Linea alba to lower end of xiphoid process; aponeuroses of obliqui and transversus abdominis to its lateral border; rectus abdominis to its ant. surface; diaphragm, transversus thoracis and costo-xiphoid lig. to post. surface.

Posterior Relations. **Manubrium:** Sterno-hyoid and sterno-thyreoid; small part of pleura and lungs. **Thymus:** left innominate vein near upper margin; aortic arch and its branches. **Body:** pleura, lungs, thymus, lymph glands and pericardium; within pericardium, asc. aorta opposite 1st segment, right auricle and portion of right atrium and ventricle opposite 2nd, 3rd, 4th segments. **Xiphoid process:** liver.

Ossification.—**Manubrium:** 1 or 2 centres appear 6th fetal month; **Body,** centres for segments, in order from above downwards, from 6th m. to full term. **Xiphoid process,** centre at 3rd year.

4th and 3rd segments of body unite in early childhood, 3rd and 2nd at puberty, 2nd and 1st from 21 to 25. Body with xiphoid at middle age, with manubrium at advanced age.

COSTÆ—RIBS

Twelve pairs. Form greater part of bony framework of thorax; overhang upper part of abdomen. Articulate with vertebrae posteriorly, provided with costal cartilages anteriorly.

First 7 pairs are called *costæ veræ* (true ribs), because their cartilages articulate with sternum. Other 5 are called *costæ spuriae* (false ribs): 11th and 12th are free at anterior ends, and are called *floating ribs*. Cartilages of 10th, 9th, 8th are connected by their borders, each to the one above, and the 8th to 7th. Ribs vary greatly in length. Longest (7th or 8th) is twice or thrice as long as shortest (1st or 12th). Typical ribs are the 3rd to 9th inclusive; 1st, 2nd, 10th, 11th, 12th have special characters.

A typical rib articulates with 2 vertebræ: the vertebra to which it corresponds numerically and the vertebra above. It consists of head, neck, tubercle, body or shaft. Body possesses an angle posteriorly, and sulcus *costæ* below.

Capitulum (Head). -- Expanded; has two facets for bodies of the two vertebræ with which it articulates. **Collum (Neck):** constricted; about 1 inch long; upper border is raised up as a crest -- *crista colli*. **Tuberculum** is placed on dorsal aspect of junction of neck and body; rough supero-laterally, smooth infero-medially for articulation with transverse process of vertebra of same number. **Corpus (Body or shaft):** long, thin, flat; curved, bent, twisted. Curvature is greatest posteriorly, and maximum point is the *angulus costæ*, marked by a ridge on external surface. **External surface** is smooth, convex, and covered by muscles. **Internal surface** is smooth, concave, and clothed with pleura. **Upper margin** is thick and rounded. **Lower margin** is grooved at expense of inner surface. This *sulcus costæ* (subcostal groove) lodges intercostal vessels and nerve, which are protected by its sharp overhanging outer margin. **Anterior end** of body is expanded and deeply pitted for costal cartilage.

Facets on **head** form a wedge: the horizontal edge between the facets is called *crista capituli*, and attached to it is an interarticular ligament, binding it to fibro-cartilage between the two vertebræ. Fibrous stratum of articular capsule is attached to margins of articular surface, and *lig. radiatum* (stellate) to ant. surface of head. Anterior surface of **neck** is smooth and clothed with pleura; posterior is rough for *lig. colli costæ* (middle costo-transverse); lower border is smooth; crest or upper border gives attachment to anterior and posterior costo-transverse lig. *Lig. tuberculi costæ* is attached to rough part of **tubercle**: fibrous stratum of articular capsule to margins of smooth facet.

Curvature of the **bodies** of ribs diminishes from above downwards in the series. Ridge which marks the **angle** gives attachment

to ilio-costalis. Near anterior end a slight accentuation of curve, called **anterior angle**, bears a roughness on external surface for origins of serratus anterior (magnus) and obliquus externus abdominis. Typical rib is bent at angle proper, so that the part posterior to angle slopes more rapidly downwards than anterior part. It is twisted also, so that inner surface of posterior part looks slightly upwards, while that of anterior part looks slightly downwards. Body is thicker posteriorly, especially at angle, where bony tissue is heaped up on the concave side to strengthen the bone at maximum of the curve *i.e.* the weakest point. Upper margin is thicker posteriorly than anteriorly; posterior intercostal membrane and both intercostal muscles are attached to it. **Costal groove** at lower border files away anteriorly, till its margins coalesce; posteriorly it broadens. Nutrient foramina in it are directed posteriorly. Ext. intercostal muscle arises from its sharp outer margin, internal intercostal from smooth rounded inner margin, and posterior intercostal membrane is attached to posterior part of groove. For other attachments see table, p. 24.

First Rib. Short, broad, sharply curved; articulates with 1st thoracic vertebra only. **Head**: small; has only one facet; articulates with body of 1st TH. vertebra and slightly with fibro-cartilage above. **Neck**: relatively long; flattened from above downwards; downturned from shaft, so that when upper surface of shaft is placed on a table, head and neck project upwards. **Tubercle**: large; articulates with 1st thoracic transverse process. **Angle** coincides with tubercle. Surfaces of **body** are superior and inferior; borders are external and internal. *External border* is convex, and thick posteriorly. *Internal border* is concave and thin; about its middle is the sharp *trunculum scaleni*, which, together with adjacent elevation on upper surface, gives insertion to scalenus anterior. *Upper surface*: shallow groove for subclavian vein anterior to scalene tubercle; better marked *subcl. sulcus* for subclavian art., posterior to it; rough depression for scalenus medius, behind subclavian groove, between it and tubercle of rib. *Lower surface* is smooth and covered with pleura. *Anterior end* is enlarged. **Costal groove** is absent.

Attachments.—Fibrous stratum of capsule and lig. radiatum to **head**. Lig. colli costæ to **neck**. Fibrous stratum of capsule and lig. tuberculi costæ to **tubercle**. Subclavius to anterior part of upper surface of **body**; scalenus ant. to *scalen. tubercle* and roughness; scalenus medius to posterior part. *External border* gives attachment to 1st intercostals, and posteriorly, where it is thick, to levator costæ, longissimus, ilio costalis, the vertebral aponeurosis and

serratus anterior. Sibson's fascia to *internal border*. Sterno-thyreoid to anterior part of *lower surface*. Pectoralis major and costo-coracoid membrane to *anterior surface* of **1st costal cartilage**; articular disc, subclavius, costo-clavicular lig. to *upper margin*; sterno-thyreoid to *posterior surface*; internal intercostal and ant. intercostal membrane to *lower margin*.

Relations.—First costal arch forms lateral boundary between neck and thorax, and a boundary between neck and axilla, as it is the medial margin of the "cervico-axillary canal." It forms the lateral margin of sup. aperture of thorax, extending from 1st thoracic vertebra to manubrium, obliquely downwards and ventrally, so that its vertebral end is above level of clavicle, while sternal end is below it; and the domes of pleura and lung extend $1\frac{1}{2}$ to 2 inches, into neck, above the level of its anterior end, but reach only to its neck posteriorly.

On the anterior border of the neck are the sympathetic trunk medially, 1st thoracic nerve laterally, superior intercostal artery and the vein from 1st intercostal space between them. The artery sends its deep cervical branch dorsally above the neck, between it and 7th cervical transverse process; and its first intercostal branch laterally along the outer border of shaft or body. The 1st thoracic nerve is passing obliquely upwards and laterally, at the junction of neck and shaft, to join the brachial plexus, and it may groove upper surface, immediately posterior to subclavian groove. It sends its 1st intercostal branch obliquely across the lower surface of the body to enter intercostal space well forwards. 8th cervical nerve passes laterally above neck to join 1st thoracic in front of scalenus medius.

Third part of subclavian artery lies in subclavian groove on upper surface, between attachments of scalenus medius and anterior, and becomes axillary artery at outer border of rib. More anteriorly, at outer border, the axillary vein becomes subclavian, which lies in groove on upper surface, in front of scalenus anterior. Clavicle crosses bony rib near anterior end, subclavian vein and subclavius intervening. Internal mammary artery descends behind the cartilage, and sends its 1st intercostal branch along the lower or external margin to meet the post. intercostal artery. Veins accompany the arteries in the intercostal space.

Pleura and lung are infero-internal relations of the arch throughout. Phrenic nerve is behind the cartilage, but separated by pleura and lung. On the right side the right innominate vein descends, posterior to the cartilage, and unites with the left vein to form superior vena cava, near its lower border; but all three veins are separated from the cartilage by overlapping pleura.

(Structures attached constitute additional relations. See p. 21.)

Second Rib.—Sharply curved. Not twisted. Angle is just lateral to tubercle. Surfaces oblique, being intermediate

in direction between those of 1st rib and of typical rib. Costal groove is poorly marked. Well-marked rough elevation, near middle of outer surface, for lower part of 1st digitation and whole of 2nd digitation of serratus anterior.

Tenth rib has usually only one facet on head, and usually a facet on tubercle.

Eleventh Rib.—Short. Only one facet on head. No facet on tubercle. Tubercle, angle and costal groove—all poorly marked.

Twelfth Rib.—Very short. Only one facet on head. Tubercle, angle and costal groove are absent.

Structures attached to 12th Rib and its Cartilage.—Articular capsule and lig. radiatum to head. Ant. and post. costal-transverse ligs., lig. colli costæ and lumbocostal lig. to neck. To outer surface: vertebral aponeurosis, *Intercostalis*, *longissimus*, *levator costæ*, *serratus posterior inferior*, *latissimus dorsi*, *obliquus externus abdominis*. To upper border: *intercostals*. To lower border: lateral lumbocostal arch (ext. arcuate lig.), *quadratus lumborum*, middle and ant. layers of lumbodorsal fascia, *obliquus internus abdominis*. To costal cartilage: diaphragm, *transversus* and *obliquus internus abdominis*, *intercostals*.

Relations of 12th Rib.—Twelfth rib forms boundary line between thorax and abdomen posteriorly; but the pleura, which, unless the rib is short, clothes only the medial $\frac{1}{2}$ or $\frac{2}{3}$ of its internal (or anterior) surface, crosses it at level of lateral border of *serratus posterior spinosus*, and extends for a varying distance below its ventral end; and the lung probably descends to the lower part of the pleura on deep inspiration. Diaphragm is separated by pleura from ant. surface medially, but is in contact with it laterally. Upper end of kidney, the suprarenal gland and perinephric fat are anterior, but separated from it by diaphragm and pleura. Branches of 11th intercostal vessels are related to its upper border. Subcostal vessels and last thoracic nerve run along its lower border, being posterior to pleura, diaphragm and lateral lumbocostal arch (ext. arcuate lig.) along the medial half of the border. Muscles of back cover its posterior surface, in its medial $\frac{1}{2}$. On the left side its tip and cartilage are separated from descending colon, at lateral border of kidney, by diaphragm and *transversus abdominis*; and the spleen often lies along level of its upper border. On the right side the liver, being anterior to kidney, is not a close relation. When rib is long its tip and cartilage are separated from upper end of ascending colon by diaphragm and *transversus*, and liver may be in close relation there. Sometimes it is so short that it does not reach beyond *sacrospinalis*, nor beyond lateral border of kidney.

Ossification of Ribs.—One primary centre appears at 6th

fœtal week, first in 6th and 7th ribs. **Three secondary centres**, one for head, one for articular part and one for non-articular part of tubercle, appear at *puberty* and have joined at 25. 11th and 12th ribs have no centre for tubercle.

CARTILAGINES COSTALES

Bars of hyaline cartilage fitted into pits at anterior ends of ribs; held there by continuity of periosteum and perichondrium. 1st cartilage is directly continuous with bony tissue of manubrium, and articular disc of sterno-clavicular joint is attached to junction. 2nd to 7th articulate with sternum by diarthrodial joints. 8th, 9th, 10th are indirectly connected with sternum through their border-to-border diarthrodial articulation with one another and with 7th. 11th and 12th lie free among muscles of flank. They increase in length from 1st to 7th, and are successively shorter below that. 1st descends obliquely, 2nd is almost horizontal. 3rd to 10th continue direction of ribs for a short distance, increasing from above downwards, and then incline upwards and medially to their terminations. 11th and 12th lie in the direction of their ribs. 10th forms lowest point of outlet of thorax, as seen from front. A line from a little behind this point to side of upper part of manubrium passes through or near junction of cartilages with ribs.

Muscles and Ligaments attached to Ribs and their Cartilages

Heads—

- Capsulæ articulares. ALL.
- Ligamenta radiata. „
- Interarticular ligaments. 2nd-9th.

Necks—

- Anterior and posterior costo-transverse ligaments. 2nd-12th.
- Lumbo-costal ligament. 12th.
- Lig. colli costæ. ALL.

Tubercles—

- Lig. tuberculi costæ. 1st-11th.
- Capsulæ articulares. 1st-10th.

Bodies—

- Subclavius. 1st.
- Scalenus anterior. 1st.
- „ medius. „
- Sterno-thyreoid. „
- Ilio-costalis cervicis. 1st-6th.
- Serratus anterior. 1st-8th.
- Ilio-costalis dorsi. ALL.

Bodies (contd.)—

External intercostals. ALL.

Internal " " "

Levatores costarum. "

Scalenus posterior. 2nd.

Pectoralis minor. 2nd-5th.

Serratus posterior superior. 2nd-5th.

Longissimus dorsi. 3rd-12th.

Obliquus externus abdominis. 5th-12th.

Subcostals, inconstant.

Ilio-costalis lumborum. 7th-12th.

Latissimus dorsi. 6th-12th.

Serratus posterior inferior. 9th-12th.

Obliquus internus abdominis. 10th-12th.

Quadratus lumborum. 12th.

Silson's fascia. 1st.

Posterior intercostal membrane. ALL.

Vertebral aponeurosis. ALL.

Lateral lumbo-costal arch. 12th.

Middle and anterior layers of lumbar dorsal fascia. 12th.

Costal Cartilages—

Sternohyoid. 1st (sometimes).

Sternothyroid. 1st.

Subclavius. 1st.

Pectoralis major. 1st-6th.

Internal intercostals. ALL.

Transversus thoracis. 2nd-6th.

Rectus abdominis. 5th-7th.

Diaphragm. 7th-12th.

Obliquus internus abdominis. 7th-12th.

Transversus abdominis. 7th-12th.

External intercostals. 6th-12th.

Articular disc of sternoclavicular joint. 1st.

Costo-coracoid membrane. 1st.

Costo-clavicular ligament. "

Anterior intercostal membranes. 1st-10th.

Sternochondral articular capsules. 2nd-7th.

Lig. sternocostal radiata. 2nd-7th.

Sternochondral interarticular ligaments. 2nd-7th, but inconstant.

Anterior and posterior costoxiphoid ligaments. 6th and 7th.

Interchondral articular capsules. 7th-10th.

THORAX

Contracted above. Diameters increase down to level

of 8th or 9th rib, below which they are slightly shorter. Broader transversely than antero-posteriorly, and antero-posterior diameter is further diminished in median plane by forward projection of vertebral bodies. **Lateral wall** is formed by ribs, which slope downwards and ventrally, not parallel but spreading, so that **intercostal spaces** are wider in front than behind. **Anterior wall** is shorter than posterior, especially in median plane; formed by sternum, anterior parts of first ten pairs of ribs and their cartilages. **Posterior wall** comprises thoracic vertebrae, and ribs as far as angles. Ribs have a backward direction as far as their angles, and form, with projecting vertebral bodies, a broad deep **sulcus pulmonalis** internally, for lodgment of thick posterior part of lung; and assist in forming broad groove externally, occupied by sacro-spinalis. Angle of 1st rib coincides with tubercle. From 2nd to 8th the distance between angle and tubercle increases. Below that it diminishes slightly.

Apertura Thoracis Superior (Inlet).—Small, reniform; its plane slopes downwards and anteriorly. *Bounded by* 1st thoracic vertebra, 1st pair of costal arches and upper margin of manubrium. *Occupied by* apices of lungs and pleurae; longi colli, sterno-hyoids, sterno-thyreoids; trachea, pretracheal fascia, oesophagus, remains of thymus; innominate, left common carotid, left subclavian, internal mammary, superior intercostal, pericardiaco-phrenic, and thyreoidea ima arteries; innominate, inferior thyreoid and 1st intercostal veins; thoracic and right lymphatic ducts; vagi nerves and sympathetic trunks and their cervical cardiac branches, left recurrent nerve, cardiac branches of right recurrent nerve, phrenic and 1st thoracic nerves; lymph glands, fat and areolar tissue.

RELATIONS AT SUPERIOR APERTURE OF THORAX

Cupola or **dome of pleura**, with underlying lung, occupies the lateral part on each side, and is roofed over by **Sibson's fascia**, which spreads fanwise from 7th cervical transverse process to inner margin of 1st rib. With the exception of the vessels and nerves in relation to neck of 1st rib of each side, the other structures occupy the interval between the two pleural sacs.

Muscles.—**Longus colli**, on each side, is ascending on the bodies of the vertebrae, covered with prevertebral fascia.

Sterno-thyreoid is ascending from post. aspect of manubrium and

1st cartilage. **Sterno-hyoid** is ascending from manubrium, superficial and lateral, to sterno-thyreoid. (Its clavicular origin is above the superior aperture of thorax.)

Viscera.—**Trachea** is descending in median plane. **Posterior** to it is the oesophagus, with the left recurrent nerve in the groove between the two. Left common carotid is on its **left side**, and left subclavian artery is passing from its left side to left side of oesophagus. Pretracheal fascia, inferior thyreoid veins, thymus, sterno-thyreoid, sterno-hyoid, manubrium are **anterior**, in that order from trachea towards skin; and, behind the thymus, the innominate artery is passing from anterior surface of trachea to its **right side**. **Pretracheal fascia** is descending upon trachea to blend with pericardium.

Oesophagus is descending upon the longus colli muscles, **posterior** to trachea and left recurrent nerve, and protruding a little to left of trachea. Common carotid artery is anterior to its **left border**; left subclavian artery is antero-lateral to its **left border**; and the thoracic duct is ascending along its left border, between it and pleura.

Thymus has manubrium, sterno-hyoid, sterno-thyreoid **anterior** to it; trachea, pretracheal fascia, inferior thyreoid veins, innominate and left common carotid arteries **posterior** to it.

Vessels. **Innominate artery** is passing upwards and to the right, from behind manubrium to the back of right sterno-clavicular joint, posterior to sterno-hyoid, sterno-thyreoid and thymus; from anterior surface to right lateral surface of trachea. A little below the inlet the inferior thyreoid veins and left innominate vein are between it and thymus.

Left common carotid artery is passing upwards and slightly laterally, from behind manubrium to back of left sterno-clavicular joint, posterior to the muscles, thymus and left innominate vein; on lateral surface of trachea, anterior to left border of oesophagus, with pleura and lung on its left side.

Left subclavian artery is ascending posterior to and to the left of common carotid, from left side of trachea to left side of oesophagus, in a groove on medial surface of pleura and lung.

Internal mammary artery, on each side, is entering thorax posterior to 1st costal cartilage, anterior to pleura. Its *vein* ends in innominate in thorax. **Pericardiaco-phrenic branch** of int. mammary artery accompanies phrenic nerve into thorax; its *vein* ends in int. mammary vein.

Superior intercostal artery, on each side, is descending on anterior surface of neck of 1st r.b. posterior to apex of pleura, between sympathetic trunk medially and 1st thoracic nerve laterally. *Vein from 1st intercostal space* ascends to root of neck in company with it.

Thyreoid ima artery, when present, ascends from innominate artery, upon anterior surface of trachea, to thyreoid gland.

Inferior thyreoid veins are descending upon trachea and pretracheal fascia, posterior to thymus, to end in innominates.

Right innominate vein is descending posterior to 1st cartilage, on right side of innominate artery, in a groove on right pleura and lung, with phrenic nerve and accompanying artery between it and pleura.

Left innominate vein is passing from behind medial end of clavicle, downwards and to the right, anterior to left common carotid, to posterior aspect of manubrium; and then, in the thorax, it passes almost horizontally, to the right and slightly downwards, posterior to thymus and the muscles, anterior to first two branches of aortic arch and trachea, near upper border of manubrium; and ends behind 1st right cartilage by joining right vein to form sup. vena cava.

Thoracic duct is ascending on left border of œsophagus, between it and pleura, having subclavian artery anterior to it, and longus colli, separated by fat, posterior to it. Thoracic part of *right lymphatic duct* is ascending upon longus colli, on the right of œsophagus.

Numerous *lymph glands* lie in relation to the various vessels.

Nerves.—**Right phrenic nerve**, having crossed int. mammary artery latero-medially, slips over rounded anterior border of pleura and lung, from anterior surface on to medial surface, accompanied by pericardiaco-phrenic artery, and enters thorax between innominate vein and pleura, a little posterior to 1st costal cartilage.

Left phrenic nerve, having crossed mammary artery, behind innominate or subclavian vein, passes off anterior surface of pleura to medial surface, and it enters thorax as it emerges from behind innominate vein. It is accompanied by pericardiaco-phrenic artery, and lies in the interval between carotid and subclavian arteries, but is as yet posterior and to the left of vagus, which it crosses after it enters thorax.

Right vagus is passing downwards and medially, postero-lateral to innominate artery, medial to pleura, to reach the side of trachea. **Left vagus** is descending between left common carotid and subclavian arteries, and has pleura in relation to its left side.

Left recurrent nerve is ascending in the groove between œsophagus and trachea. Right recurrent nerve arises above the level of the inlet.

Cervical cardiac branches of vagus and sympathetic, on each side, are descending in company with vagus. *Cardiac branches of right recurrent nerve* are descending on the side of trachea.

Sympathetic trunk on each side, is descending on anterior aspect of neck of 1st rib, posterior to apex of pleura; and here the inferior cervical ganglion is usually fused with first thoracic ganglion.

First thoracic nerve, on each side, is passing obliquely, laterally and upwards, posterior to pleura, across anterior surface of junction of neck and body of 1st rib, to join brachial plexus, and is giving off the 1st intercostal nerve.

Apertura Thoracis Inferior (Outlet).—Large, irregular. Occupied by diaphragm and other structures (see Diaphragm).

Bounded by 12th thoracic vertebra, 12th pair of ribs, 12th to 7th costal cartilages, xiphi-sternal junction. Line drawn along boundary passes downwards, laterally and anteriorly along 12th rib, horizontally from 12th to 11th cartilage, slightly upwards to 10th, sharply upwards, anteriorly and medially, along 9th, 8th, 7th cartilages, to xiphi-sternal junction.

Angulus Infrasternalis.—Bounded on each side by 7th costal cartilage. Apex is at xiphi-sternal junction. Xiphoid process forms its floor.

BONES OF THE SKULL

Ossa Cranii. Paired: parietals, temporals, inferior nasal conchae (inferior turbinated), lacrimals, nasals. Unpaired: frontal, occipital, sphenoid, ethmoid, vomer.

Ossa Faciei. Paired: maxilla, zygomatics, palatine. Unpaired: mandible.

Note.—Position, parts, articulations and ossification are given here in connection with and vidual bones, but most of the details are included only in the account of *skull as a whole*, except in case of *mandible*.

Os Frontale. Situated in anterior part of cranium. Formed by fusion in early life of 2 symmetrical halves.

Squama frontalis is the large part which forms forehead. Its **frontal surface** is convex and ends below in median **margo nasalis** (nasal notch), which articulates with nasal bones and frontal processes of maxilla, and laterally on each side in the curved **margo supraorbitalis**, medial end of which, called **medial angular process**, articulates with lacrimal, while lateral end, **processus zygomaticus** (external angular process), articulates with zygomatic (malar). **Cerebral surface** is concave.

Pars orbitalis. Two triangular plates which form greater part of roofs of orbits. Connected with squama anteriorly and laterally, and, with it, form a deep fossa for frontal lobes of cerebrum. Circumferential margin of this fossa articulates with parietals above, wings of sphenoid below, area for great wing being large and triangular. Orbital plates are separated by deep **incisura ethmoidalis**, which is occupied by lamina cribrosa of ethmoid. On each side of notch there are several broken cavities, which are completed by articulation with labyrinth of ethmoid.

Pars nasalis is the area anterior to ethmoidal notch. **Spina frontalis** projects from its centre and articulates with nasal bones anteriorly and perpendicular lamina of ethmoid posteriorly. Groove

on each side of spine helps to form roof of nasal cavity. At the side of the groove an opening leads up into **sinus frontalis**.

Ossification.—In membrane. Centre for each half appears at 8th fetal week. Halves are separate at birth. Fusion complete at 8th year, except inferiorly. **Frontal sinuses**, recognisable at 7th year, but not fully developed till after puberty.

Os Parietale.—Lies at side and top of head. **Parietal surface** convex, maximum point being called **tuber parietale** (parietal eminence). **Cerebral surface** concave. **Margo sagittalis** articulates with opposite parietal; **margo frontalis**, with frontal; **margo occipitalis**, with occipital; **margo squamosus**, curved and bevelled, with squamous temporal. **Angulus sphenoidalis** (antero-inferior) sharp and projecting, articulates with great wing of sphenoid; **angulus mastoideus** (postero-inferior) blunt, articulates with mastoid temporal. **Angulus frontalis** and **angulus occipitalis** are the antero-superior and postero-superior angles.

Ossification.—In membrane. Centre appears at parietal tuber at 8th fetal week.

Os Occipitale.—Placed at back and base of cranium. Consists of 4 parts arranged around **foramen magnum**: basilar part anteriorly, squamous part posteriorly, lateral (condylic) parts at sides. All separate at birth; fused by 5th year.

Squama occipitalis.—**Anterior surface** is related to occipital lobes above, to cerebellum below; **posterior surface** is divided into **planum occipitale** above, **planum nuchale** below. **Angles**: superior and 2 lateral. **Margo lambdoideus**, above lateral angle, articulates with parietals. **Margo mastoideus**, below lateral angle, with mastoid temporal. **Ossification.**—Upper part, in membrane, by 2 centres appearing at 8th week; lower part, in cartilage, by 2 centres appearing at 8th week. Two parts join during 3rd fetal month.

Pars lateralis consists of **condylus occipitalis**, medially, which articulates with atlas; and **processus jugularis**, laterally, which articulates with petrous temporal. **Ossification.**—1 centre appears at 8th week.

Pars basilaris.—Fused anteriorly with sphenoid. **Surfaces**: upper (clivus) and lower. **Borders**: 2 lateral, articulating with petrous temporal. **Ossification.**—1 centre appears at 9th week.

Os Temporale lies at side and base of skull. Consists of squamous part above and anteriorly; petrous part medially, mastoid part posteriorly, tympanic part below.

Squama temporalis (Squamous temporal).—**Surfaces**: lateral or temporal, medial or cerebral. **Margo parietalis** articulates with parietal, superiorly; **margo sphenoidalis**, with great wing of sphenoid, anteriorly. **Processus zygomaticus** (zygoma) projects anteriorly to articulate with zygomatic (malar). **Ossification.**—In membrane. 1 centre appears at 8th week.

Pars petrosa (Petrus temporal), pyramidal. Hardest bone in body. **Surfaces**: anterior, posterior, inferior. **Apex** articulates with sphenoid, in angle between great wing and body. **Base**, fused with mastoid. (Original fetal anterior surface is partly fused with squamous and tympanic parts, and partly free, forming medial boundaries of tympanic cavity and antrum, and of canals for auditory tube and tensor tympani.) **Borders or Angles**: *Superior* gives attachment to tentorium; *anterior* partly articulates with great wing of sphenoid and is partly fused with squamous; *posterior* articulates with basilar part of occipital. **Processus styloideus** projects from lower surface, downwards and anteriorly. **Ossification**.—In cartilage. 4 centres appear at 5th fetal month and rapidly fuse. Styloid process is ossified from cartilage of 2nd visceral arch by 2 centres which appear just before and after birth, and fuse in adult life.

Pars mastoidea.—**Surfaces**: *lateral* gives attachment to muscles; and *medial* forms part of post. cranial fossa. **Margo occipitalis** articulates with occipital, posteriorly. **Margo parietalis**, with parietal, above. **Processus mastoideus** projects downwards. **Ossified** by extension from petrous.

Pars tympanica.—A curved plate forming anterior, inferior and posterior walls of external acoustic meatus. **Ossification**.—1 centre appears at end of 3rd month.

At birth, tympanic part is not a plate but a ring, incomplete above; and temporal bone consists of squamous, petro-mastoid, tympanic ring, and base of styloid—which all join during 1st year.

Os Sphenoidale lies in base and at sides of skull, anterior to occipital and temporals, posterior to frontal and ethmoid. Consists of body, 2 small wings, 2 great wings, 2 pterygoid processes.

Corpus encloses 2 large sinuses, which appear about 7th year. **Surfaces**: *superior*; 2 *lateral* articulate with apices of petrous temporal; *inferior*, with vomer and sphenoidal process of palatine; *anterior*, with ethmoid and orbital process of palatine; *posterior*, fused with basilar part of occipital after 25th year.

Ala parva projects laterally from anterior and upper part of body. Its two **roots** enclose optic foramen. **Surfaces**: superior, inferior. **Borders**: *anterior* articulates with orbital plate of frontal; *posterior* is free and ends medially as **anterior clinoid process**.

Ala magna projects laterally from lateral surface of body. **Surfaces**: orbital, cerebral, temporal, infra-temporal, spheno-maxillary. **Borders**: *posterior* forms anterior margin of foramen lacerum, and articulates with petrous temporal; *postero lateral* **margo squamosus** articulates with squamous temporal; *antero-medial* forms lower margin of superior orbital fissure; *antero-inferior* forms upper margin of inferior orbital fissure. Upper edges of cerebral, orbital and temporal surfaces enclose a triangle (**margo frontalis**) which articulates with frontal. Anterior edges of temporal and orbital

surfaces form a border (*margo zygomaticus*) which articulates with zygomatic (malar).

Processus pterygoideus projects downwards from junction of lateral surface of body and great wing. Consists of *lamina medialis* and *lateralis*. Anteriorly the laminae are joined above. **Fissura pterygoidea** separates them below, and is occupied by pyramidal process of palatine. **Fossa pterygoidea** lies between the laminae posteriorly.

Ossification.—*Medial lamina* in membrane. 1 centre appears at 9th week, fuses with centre for great wing in 4th month. In **post-sphenoid**—*i.e.* behind level of tuberculum sellae (olivary eminence)—1 centre for *great wing* and *lateral pterygoid lamina* at 8th week, and 4 for *body*, including lingula, during 3rd and 4th months. In **presphenoid**, 1 centre for each *small wing* at 9th week, fuses with body during 4th month, and 2 for *body* appear at 10th week and fuse with each other and with post-sphenoid during 8th month. **Sphenoidal conchæ** (turbinated bones), fused after 6th year with front and under surface of body, have each 1 or 2 centres after 5th month. **At birth**, sphenoid is in three pieces: great wing and pterygoid process on each side; body with small wings. They fuse during 1st year.

Os Ethmoidale lies anterior to sphenoid, between the orbits. Consists of 2 labyrinths united to median perpendicular lamina by lamina cribrosa.

Lamina perpendicularis forms part of septum nasi. **Borders:** *superior* projects into cranial cavity as **crista galli**. *Posterior* articulates with sphenoid; *postero-inferior*, with vomer; *antero-inferior*, with septal cartilage; *antero-superior*, with frontal and nasal.

Labyrinthus.—Very thin bone, enclosing air-cells. **Surfaces:** *superior* is covered by and articulates with orbital plate of frontal; *posterior* articulates with sphenoid and orbital process of palatine; *anterior* is covered by and articulates with lacrimal and frontal process of maxilla; *lateral*, in medial wall of orbit, closed in by lamina papyracea. *Medial*, free in lateral wall of nasal cavity. **Processes:** conchæ, superior and middle (turbيناتes), and processus uncinatus, all on medial surface.

Lamina cribrosa lies horizontally at sides of crista galli.

Ossification.—In cartilage. **Labyrinth:** 1 centre appears at 6th month. **Perpendicular lamina:** 2 centres, at end of 1st year. *Lamina cribrosa* by extensions from the other parts. Fusion completed at 6th year, but ossification not completed till puberty.

Concha Nasalis Inferior (inf. turbinated) projects into nasal cavity from its lateral wall. **Surfaces:** *medial* looks into nasal cavity; *lateral* overhangs inferior meatus. **Borders:** *superior* articulates with palatine, ethmoid, lacrimal, frontal process of

maxilla. *Inferior* is free. **Ossification**: in cartilage, 1 centre at 5th month.

Os Lacrimale.—**Surfaces**: *medial* lies against ethmoid and looks into nasal cavity; *lateral* forms part of medial wall of orbit. **Borders**: *superior* articulates with frontal; *anterior*, with frontal process of maxilla; *posterior*, with lamina papyracea; *inferior*, with maxilla and concha inferior. **Process**: *hamulus lacrimalis* on lateral surface. **Ossification**: in membrane, 1 centre at 9th week.

Vomer.—Forms posterior part of nasal septum. **Borders**: *superior* splits into 2 *alæ* and articulates with sphenoid; *anterior* articulates with perpendicular lamina of ethmoid and septal cartilage; *inferior*, with nasal crests of palatine and maxilla; *posterior* is free. **Ossification**: in membrane, 2 centres, one on each side, at 8th week. The two plates have coalesced at puberty.

Os Nasale.—Lies in bridge of nose. **Surfaces**: lateral, medial. **Borders**: *anterior* articulates with its fellow, and posteriorly with frontal spine, lamina perpendicularis, septal cartilage; *posterior* articulates with frontal process of maxilla. **Ends**: *superior* articulates with nasal notch of frontal; *inferior* is attached to lateral nasal cartilage. **Ossification**: in membrane, 1 centre at 8th week.

Maxillæ form upper jaw. Each consists of body and 4 processes—frontal, zygomatic, alveolar, palatine.

Corpus.—Encloses *sinus maxillaris* (antrum of Highmore). **Surfaces**: *anterior* (facial); *infra-temporal* (posterior) ends below in *tuber maxillare*; *orbital* (superior) articulates by its medial border with lacrimal, ethmoid, and orbital process of palatine; *nasal* (medial) shows opening into maxillary sinus and groove for naso-lacrimal duct; articulates with palatine and inferior concha.

Processus frontalis projects upwards and medially; forms part of nose. **Upper end** lies against and articulates with anterior aspect of ethmoid and nasal notch of frontal. **Surfaces**: *medial* articulates with middle and inferior conchæ. *Lateral* is partly in bridge of nose and partly in orbit, and is grooved in orbit for lacrimal sac (*sacculus lacrimalis*). **Borders**: *anterior* articulates with nasal; *posterior*, with lacrimal.

Processus zygomaticus projects laterally and articulates with zygomatic malar). **Processus alveolaris** projects downwards and bears the teeth.

Processus palatinus projects medially; helps to form floor of nasal cavity and roof of mouth. *Medial border* articulates with its fellow and with vomer; *posterior* articulates with palatine.

Ossification.—In membrane, 2 centres—1 for main part of bone, 1 for *os incisivum* (premaxilla), *i.e.* part carrying incisor teeth, and line of its fusion can be seen in young skull—appear at 6th week; are fused at 3rd month. Alveolar process begins to appear at 4th

month, but is not fully developed till permanent teeth have appeared. Maxillary sinus appears at 4th month, but is not fully developed till after puberty.

Os Palatinum consists of a perpendicular and a horizontal part, joined to each other at a right angle. **Pars perpendicularis.**—**Surfaces:** *maxillary* (lateral) lies against nasal surface of maxilla; *nasal* (medial) articulates with middle and inferior conchæ. **Borders:** *anterior* projects over opening of maxillary sinus; *posterior* articulates with medial pterygoid lamina. **Processus orbitalis** and **sphenoidalis** project from upper end and bound **incisura sphenopalatina** (**spheno palatine notch**); sphenoidal articulates with sphenoid and vomer; orbital, with sphenoid, ethmoid and maxilla.

Pars horizontalis.—Forms posterior part of hard palate. **Surfaces:** superior, inferior. **Borders:** *medial* articulates with its fellow and vomer; *anterior*, with palatine process of maxilla; *posterior* is free.

Processus pyramidalis projects postero-laterally from junction of the two parts and fits into pterygoid fissure and between pterygoid process and maxilla.

Ossification.—In membrane, 1 centre at 8th week.

Os Zygomaticum (malar) forms prominence of cheek. **Surfaces:** malar (lateral), orbital, temporal. **Borders:** *superior* or orbital; *posterior* gives attachment to temporal fascia, *inferior* to masseter; *anterior* articulates with maxilla. **Processes:** *fronto-sphenoidal* articulates with frontal and great wing of sphenoid; *temporal*, with zygoma. **Ossification:** in membrane, 1 centre appears at 8th week.

Mandible consists of body and 2 rami, each ramus surmounted by condyle and coronoid process.

Corpus.—Two symmetrical halves fused during 1st or 2nd year at *symphysis*. **Lateral surface:** At symphysis a faint ridge ends below in triangular *mental protuberance*, at basal angles of which are the *mental tubercles*. From each tubercle the *oblique line* extends to ramus. From the line the triangularis and quadratus labii infer. arise; platysma is inserted below it. Above the line, opposite 2nd premolar, is the *mental foramen*, which transmits mental vessels and nerve. *Juga alveolaria* are ridges produced by incisor and canine teeth. Below them is *incisor fossa*, from which mentalis and orbicularis arise. Buccinator is attached at alveolar margin, opposite molar teeth. **Medial surface:** At each side of symphysis 2 *mental spines*, which may be fused, give origin to genio-glossus and genio-hyoid. From below them the *mylo-hyoid line* extends posteriorly and upwards. It gives origin to mylo-hyoid; and fascia on deep surface of submaxillary gland

is attached to it; sup. constrictor and pterygo-mandibular raphe are attached to its posterior end. Above it, near symphysis, is *fovea sublingualis* for sublingual gland; below it, *fovea submaxillaris* for submaxillary gland. **Basis mandibulæ** (inferior border) gives attachment to deep fascia of neck, and displays at side of symphysis the *digastric fossa*, for origin of anterior belly of digastric; and it ends posteriorly at **angulus mandibulæ**. **Limbus alveolaris** superior border supports teeth.

Ramus.—**Lateral surface** gives insertion to masseter. **Medial surface** presents *foramen mandibulare*. It transmits inferior alveolar (dental) vessels and nerve, and is bounded antero-medially by *lingula*, to which speno-mandibular lig. is attached. *Mylo-hyoid sulcus*, for mylo-hyoid vessels and nerve, runs downwards and anteriorly from the foramen. Posterior and inferior to sulcus the surface is rough for insertion of pterygoideus internus. Superior constrictor is attached just posterior to last molar. On superior border is **incisura mandibularis** (sigmoid notch), which transmits nerve and vessels to masseter. It is bounded posteriorly by **processus condyloideus**, which consists of *capitulum* (head), for articulation with squamous temporal, and *collum* (neck), around which articular capsule is attached. On anterior surface of neck is *fovea pterygoidea* for insertion of pterygoideus externus. **Processus coronoideus** is anterior to incisura; temporal muscle is attached to its tip and medial surface, and to anterior border of ramus. Posterior border of ramus is thick and ends below in **angle**, which gives attachment to stylo-mandibular ligament.

Ossification.—In membrane surrounding cartilage of mandibular arch (Meckel's); 1 centre for each half appears in lateral surface of membrane at 6th week.

Os Hyoideum.—Lies in the neck, between mandible and larynx, opposite 3rd c. vertebra. Easily felt. Developmentally connected with skull. Consists of body, and 2 lesser and 2 greater horns.

Corpus. **Posterior surface**: concave; separated from thyreo-hyoid membrane by bursa. **Anterior surface**: roughened for attachment of deep fascia of neck, mylo-hyoid, hyo-glossus; fascia binding intermediate tendon of digastric, and stylo-hyoid at junction with greater horn. **Upper border**: broad; gives attachment to genio-hyoid, genio-glossus,

hyo-epiglottic ligament, thyreo-hyoid membrane. **Lower border** gives insertion to sterno-hyoid, omo-hyoid, thyreo-hyoid, and levator glandulae thyroideae.

Cornu majus curves posteriorly and upwards from side of body. It is connected with body in early life by synchondrosis, but fuses at middle age. Thyreo-hyoid, hyo-glossus, middle constrictor are attached to its lateral surface, thyreo-hyoid membrane to its medial surface, and lateral thyreo-hyoid ligament to its free end.

Cornu minus, a little nodule, projecting upwards and posteriorly from junction of body and greater horn, articulates there by diarthrodial joint till after middle age, when it fuses. Stylo-hyoid lig. and middle constrictor are attached to it.

Ossification.—1 or 2 centres for body at 8th month, 1 for greater horn at 9th month, 1 for lesser horn in 1st year. Body developed from cartilages of 2nd and 3rd visceral arches, lesser horn from 2nd cartilage, greater horn from 3rd.

SKULL AS A WHOLE

ANTERIOR ASPECT OF SKULL

Frontal Region.—Formed by frontal bone. Maximum convexity, on each side, is *tuber frontale* (frontal eminence), overlying middle frontal gyrus. **Boundaries:** **Superiorly** it merges into vertex. **Lateral:** *linea temporalis* curves posteriorly from zygomatic process (ext. angular). **Inferior:** *nasal margin* (nasal notch) in middle; *supra-orbital margin* at each side. Nasal margin articulates with nasals and frontal processes of maxillae. Supra-orbital margin ends medially in *medial angular process*, which articulates with lacrimal, and laterally in *zygomatic process*, which articulates with zygomatic bone; *supra-orbital notch* or *foramen*, at junction of medial and middle thirds, transmits supra-orbital artery and nerve. *Nasion* is centre of fronto-nasal suture. Above it, is *glabella*, a transverse ridge interrupted by remains of median *frontal suture*, and uniting *superciliary arches*, which are situated above supra-orbital margin and overlie frontal sinuses.

Orbits.—Four-sided pyramids, directed anteriorly and

laterally; medial walls parallel to one another. **Aditus orbitæ** or **base**: bounded *above* by supra-orbital margin; *laterally* by zygomatic bone (malar and zygomatic process of frontal; *below* by zygomatic and maxilla; *medially* by frontal process of maxilla and medial angular process of frontal. **Apex** is the medial end of superior orbital fissure (sphenoidal fissure). **Superior wall** or **roof**: orbital plate of frontal anteriorly, small wing of sphenoid posteriorly. *Fossa glandulæ lacrimalis* lies under shelter of zygomatic process. *Fora (vel spina) trochlearis*, for pulley of obliquus superior, lies above medial angular process. **Lateral wall**: great wing of sphenoid posteriorly, zygomatic (malar) anteriorly. **Inferior wall**: maxilla; zygomatic antero-laterally, and orbital process of palatine at post. angle. **Medial wall**: frontal process of maxilla, lacrimal, lamina papyracea (os planum) of ethmoid, side of body of sphenoid, in that order from before backwards.

Sutures: those between the various bones.

Foramina, etc.—Between roof and medial wall: *foramen opticum*, between body of sphenoid and roots of small wing; *transmits* optic nerve, ophthalmic artery and sympathetic twigs from carotid plexus. *Anterior* and *posterior ethmoidal foramina*, between orbital part of frontal and labyrinth of ethmoid, open into anterior cranial fossa; *transmit* ant. and post. ethmoidal vessels and nerves.

Between roof and lateral wall: *superior orbital fissure* (sphenoidal fissure), between body and wings of sphenoid; *transmits* ophthalmic veins, upper and lower divisions of oculo motor nerve, trochlear nerve; frontal, naso-ciliary (nasal) and lacrimal branches of ophthalmic division of trigeminal nerve; abducent nerve; sympathetic twigs from carotid plexus; recurrent branch to meninges from ophthalmic or lacrimal artery; and sometimes an orbital branch from middle meningeal artery.

Between floor and lateral wall: *inferior orbital fissure* (spheno-maxillary fissure), bounded by great wing of sphenoid, zygomatic (malar), maxilla, orbital process of palatine; *transmits* maxillary division of trigeminal nerve as it becomes infra-orbital nerve, infra-orbital vessels, zygomatic (temporo-malar or orbital) nerve, a vein connecting ophthalmic veins with pterygoid plexus, small twigs from spheno-palatine ganglion to periosteum of orbit.

Between floor and medial wall: *lacrimal groove* for lacrimal sac, on lacrimal bone and frontal process of maxilla, leads down, between medial wall and floor, into *naso-lacrimal canal* for the naso-lacrimal duct, which opens into inferior meatus of nose.

On lateral wall: *zygomatico-orbital foramen*, on orbital surface of zygomatic (malar), *transmits* zygomatic (temporo-malar) nerve and a branch of lacrimal artery.

On the floor: *infra-orbital groove* extends from inferior orbital fissure across orbital surface of maxilla to *infra-orbital canal*, which opens on face as *infra-orbital foramen*. Infra-orbital vessels and nerve traverse all three.

Relations of Orbit.—*Above*: ant. cranial fossa, frontal sinus. *Below*: maxillary sinus, infra-temporal fossa. *Posterior*: middle cranial fossa. *Lateral*: temporal fossa. *Medial*: sphenoidal and ethmoidal air-cells, nasal cavity.

Facial Region.—*Dorsum nasi*, between orbits, formed by nasal bones and frontal processes of maxillæ. Below it, is *apertura piriformis*, bounded by these bones and by anterior margin of maxilla, which ends below as *spina nasalis anterior*. Below the aperture is the *incisor fossa*, lateral to which is the *canine eminence*. Lateral to that is the *fossa canina*, above which is the *infra-orbital foramen*. Lateral to maxilla is malar surface of zygomatic, presenting *foramen zygomatico-faciale*, which *transmits* zygomatico-facial branch of zygomatic (temporo-malar) n. and a branch of lacrimal artery.

LATERAL ASPECT OF SKULL

Bones, from behind forwards: *Above*, occipital, parietal, frontal. *Below*, occipital, temporal, sphenoid. *Anteriorly and below*, bones of face:—see Anterior Aspect, p. 36.

Sutures.—Between the various bones.

Regions.—*Pterion*, where frontal, parietal, temporal and great wing of sphenoid lie close together, $1\frac{1}{2}$ inches above zygomatic arch, $1\frac{1}{4}$ inches behind zygomatic process of frontal. Occupies position of fonticulus sphenoidalis (fontanelle)—closed shortly after birth. Overlies anterior branch of mid-meningeal artery and point where lateral fissure of cerebrum (Sylvius) breaks up into its three branches. *Asterion*, where parietal, occipital and mastoid meet; transverse sinus begins to bend down just anterior to it. Occupies position of fonti-

culus mastoideus—closed shortly after birth. **Stephanion**, where temporal line crosses coronal suture. **Tuber parietale** (parietal eminence) is the maximum convexity of parietal bone, overlies supra-marginal gyrus.

Linea Temporalis.—Usually double. Begins at zygomatic process (ext. angular) of frontal, arches posteriorly over frontal, parietal, and turns down to join **supra-mastoid crest** on squamous temporal, near junction with mastoid. This crest joins posterior root of zygoma, above meatus.

Meatus acusticus externus is bounded superiorly by squamous temporal; anteriorly, inferiorly and posteriorly by tympanic plate. **Medial wall of tympanum** is seen when one looks into meatus; it displays the *promontory*, produced by first coil of cochlea, with *fenestra vestibuli* ovalis above promontory, *fenestra cochleæ* rotunda below. **Supra-meatal triangle** is a depression at the crossing of tangents to upper and posterior borders of meatus. Tympanic antrum lies $\frac{1}{2}$ – $\frac{3}{4}$ inch inwards and slightly forwards from it. *Spina supra meatum*, on antero-inferior margin of triangle, is rarely seen. *Tympano-mastoid fissure* (auricular fissure), between tympanic plate and mastoid, transmits auricular branch of vagus.

Arcus zygomaticus is formed by zygomatic bone (malar) and zygomatic process (zygoma) of temporal. **Lateral surface**, subcutaneous; **medial surface** and **lower border** give origin to masseter. Temporal fascia is attached to **upper border**. **Posterior root of zygoma** runs posteriorly above meatus from upper border. **Anterior root** turns medially from lower border and is continuous with tuberculum (eminentia) articulare. *Tubercle of root of zygoma*, where the roots join, gives origin to temporo-mandibular ligament.

Fossa Temporalis.—**Outlined** by zygomatic (ext. angular) process of frontal, temporal line, supra-mastoid crest, posterior root of zygoma, zygomatic arch, frontal process of zygomatic (malar). Temporal fascia is attached to all these. **Medial wall** gives origin to temporalis. It is formed by parietal, frontal, squamous temporal, great wing of sphenoid; is limited below by *crista infratemporalis*, on which grooves for deep and middle temporal arteries may be found. **Anterior wall**: zygomatic process of frontal, fronto-sphenoidal process of zygomatic, on which is *foramen zygomatico-temporale*, which transmits zygomaticotemporal branch of zygomatic temporo-malar nerve, and a branch of lacrimal artery. **Lateral wall** is the zygomatic arch. The fossa

communicates with orbit through inferior orbital fissure, and with infra-temporal fossa directly.

Fossa Infratemporalis (Zygomatic Fossa; Pterygo-maxillary Space).—**Lateral wall**: ramus and coronoid process of mandible. **Anterior wall**: maxilla, presenting *tuber maxillare* behind 3rd molar, and *foramina alveolaria* for posterior superior alveolar (dental) vessels and nerves to molar teeth. **Medial wall**: lateral pterygoid lamina, and pyramidal process of palatine wedged between it and maxilla. **Roof**: infra-temporal (zygomatic) surface of great wing of sphenoid. The fossa *communicates* with orbit through inferior orbital fissure; with pterygo-palatine (spheno-maxillary) fossa through pterygo-maxillary fissure. **Pterygo-maxillary fissure** is bounded by maxilla anteriorly, pterygoid process posteriorly, pyramidal process of palatine below. Joins inferior orbital fissure above. Transmits internal maxillary vessels and the maxillary nerve.

Fossa Pterygo-palatina (spheno-maxillary) is bounded by maxilla in front; great wing of sphenoid and pterygoid process behind; perpendicular part of palatine medially. Roof is body of sphenoid and orbital process of palatine. **Contents**: maxillary nerve, spheno-palatine ganglion, terminal branches of internal maxillary artery, and accompanying veins, fat and fibrous tissue. **Foramina, etc.**, connected with it: (1) *For. spheno-palatinum*, between spheno-palatine notch of palatine and body of sphenoid, leads into nasal cavity; *transmits* spheno-palatine vessels and naso-palatine nerve, and one or more superior nasal nerves from spheno-palatine ganglion. (2) *Pharyngeal canal* (pterygo-palatine), between vaginal process of sphenoid and sphenoidal process of palatine; leads posteriorly and medially to pharynx; *transmits* pharyngeal artery and pharyngeal branch of spheno-palatine ganglion. (3) *Pterygoid canal* (Vidian) traverses root of pterygoid process to gain foramen lacerum, and *transmits* artery and nerve of pterygoid canal (Vidian art. and n.). (4) *For. rotundum*, in great wing, opens into middle cranial fossa; *transmits* maxillary division of trigeminal n. (5) *Greater palatine canal* (B.N.A. canalis pterygo-palatinus) leads down between maxilla and perpendicular part of palate to roof of mouth; *transmits* descending palatine vessels, anterior palatine nerve. (6) Two *lesser palatine canals* pass down through pyramidal process of palatine, and end on its lower surface as *foramina palatina minora*; *transmit*

lesser palatine arteries, middle and posterior palatine nerves. (7) *Inferior orbital fissure* (p. 37) leads into orbit. (8) *Pterygo-maxillary fissure* leads into infra-temporal fossa.

POSTERIOR ASPECT OF SKULL

Bones.—Parietals above, occipital below, mastoid temporals laterally. **Sutures**: those between the bones.

Points and Lines.—**Lambda**, at apex of occipital, where sagittal and lambdoid sutures meet, lies opposite mid point between parieto-occipital fissures of brain. Occupies position of fonticulus occipitalis post. fontanelle—closed shortly after birth. **External occipital protuberance** inion, near centre of occipital squama, gives attachment to trapezius and lig. nuchæ. **External occipital crest** descends from protuberance to for. magnum, gives attachment to lig. nuchæ. **Linea nuchæ superior** arches laterally from protuberance; trapezius, sterno-mastoid, splenius and occipitalis are attached to it. **L. nuchæ suprema**, above superior, gives attachment to galea aponeurotica (epicranial aponeurosis). **L. nuchæ inferior** extends laterally from middle of occipital crest. Semispinalis capitis (complexus) and obliquus superior are inserted into area between L. sup. and inf.: rectus posterior major and minor, below L. inferior.

Foramina.—**F. mastoideum**, on mastoid temporal at or near occipital border, leads into groove for transverse lateral sinus; *transmits* emissary vein and meningeal branch of occipital art. **F. parietale**, $1\frac{1}{2}$ inch above lambda; *transmits* emissary vein to superior sagittal (longitudinal) sinus.

SKULL VIEWED FROM ABOVE

Bones.—Frontal, parietals, occipital. **Sutures**: coronal, sagittal, lambdoid.

Points, etc.—**Bregma**, where sagittal meets coronal suture. Situated at mid point of line drawn across top of head from front of one ear to that of the other. May be felt as a depression. Marks the position of fonticulus frontalis (ant. fontanelle—closed during 2nd year. **Obelion** is the point on sagittal suture between parietal foramina. **Vertex**, highest point on sagittal suture; position variable. **Lambda**, parietal foramina, tubera parietalia, lineæ temporales and stephanion are dealt with earlier.

BASIS CRANII EXTERNA

Antero-median Area.—**Bones:** maxillæ, palatine, body of sphenoid, pterygoid processes, vomer. **Sutures:** s. palatina mediana and transversa, pterygo-palatine, spheno-vomerine. **Hard palate:** formed by palatine processes of maxillæ and horizontal parts of palatine bones. Bounded *anteriorly* and *laterally* by alveolar processes, which bear teeth, and end posteriorly in *tuber maxillare* on each side. *Posterior margin*, free, gives attachment to soft palate; projects backwards in middle as *posterior nasal spine*, from which musculus uvulae arises. **Foramina:** *F. incisivum*, posterior to incisor teeth; 2 pairs of canals lead into it from nose—*foramina of Stenson*, laterally, transmit greater palatine arteries (ascending to nose); *foramina of Scarpa*, in the suture, transmit naso-palatine nerves (descending to palate). *For. palatinum majus*, at postero-lateral angle, is the lower end of greater palatine canal. Greater palatine art. runs anteriorly from it in groove near alveolar process; posterior to it is *palatine crest* for insertion of tensor veli palatini; posterior to crest is one *foramen palatinum minus*, and lateral to it the other, when present.

Choanæ (Posterior Nares).—1 to $1\frac{1}{2}$ inch long; $\frac{1}{2}$ inch broad; look backwards and downwards. Bounded *below* by palatine; *above*, by sphenoid covered by ala of vomer and vaginal process; *medially*, by vomer; *laterally*, by medial pterygoid lamina.

Pterygoid process consists of medial and lateral laminae, which bound pterygoid fossa; the upper parts of their anterior borders are joined, but lower parts are separated by pterygoid fissure. *Lamina medialis*, narrower than *lateralis*, ends below in *hamulus pterygoideus*, on under surface of which tendon of tensor veli palatini turns medially to palate. Superior constrictor and pterygo-mandibular raphe arise from posterior border and hamulus. *Processus vaginalis* projects medially from upper end of medial lamina to articulate with ala of vomer. *Pharyngeal canal* (p. 40) is seen lateral to this articulation. *Pterygoid tubercle* is at upper end of posterior border of medial lamina, on anterior margin of *for. lacerum*. *Fossa scaphoidea*, below and lateral to tubercle, gives origin to tensor v. palatini. *Pterygoid (Vidian) canal* (p. 40) is above and

lateral to tubercle, on anterior margin of for. lacrim. *Foramen of Lacrim.*, often absent, above and lateral to sphenoid for. a, *transmits* vein between cavernous sinus and pterygoid plexus.

Processus pyramidalis ossis palatini, wedged in between maxilla and pterygoid process, appears in infra-temporal for. a between them, fills up pterygoid for. a between pterygoid laminae and assists them in forming pterygoid for. a. *Foramina palatina minora* are on its lower surface. Superficial head of pterygoiden externus arise from its lateral surface and from other maxillare, deep head from its posterior surface between pterygoid laminae, and from medial surface of lateral pterygoid lamina.

Antero lateral Area. **Bones** zygomatic (malar) process of maxilla, zygomatic arch, infra-temporal surface of squamous temporal and of great wing of sphenoid. **Sutures** zygomatico-macillary, zygomatico-temporal, sphenosquamous. **Foramina, etc.** *For. orbital post.* margin of great wing, near pterygoid process, *transmits* mandibular division of trigeminal n., accessory (small) meningeal art., small vein, between cavernous sinus and pterygoid plexus, meningeal lymphatics passing to upper deep cervical glands; lower superficial petrosal nerve, sometimes. *For. spinosum*, postero-lateral to ovale, *transmits* middle meningeal vessels. Ramus posterior, recurrent branch of mandibular nerve, meningeal lymphatics passing to upper deep cervical glands. *Spina angularis*, postero-lateral to *For. spinosum* gives origin to pharyngeal bulbular and tensor palatini chorda tympani groove on medial side. *Infratemporal for.*, vein between sphenoid and maxilla. *Infra-temporal crest* is at lateral margin of infra-temporal surface. Upper head of pterygoiden externus arise from infra-temporal crest and surface, lower head from lateral surface of lateral pterygoid lamina.

Postero median Area. **Bone** occipital. **Pars basilaris** of occipital, anterior to for. magnum, marked off from sphenoid by irregular groove. *Tuberculum pharyngeum*, about its centre, gives attachment to median raphe of pharynx and fibres of up-constrictor. *Impressurae* (1) for insertion of longus capitis rectus major, antero-lateral to tubercle; (2) for rectus cap. anterior (minor), immediately anterior to condyle. **Foramen magnum**. *Content* spinal medulla (cord), its vessels, its membranes, spinal roots of accessory nerves, vertebral arteries, with plexus of sympathetic nerves.

from inf. cervical ganglion, and meningeal lymphatics passing to deep cervical glands; *membrana tectoria*; lower part of cerebellum. Ant. and post. atlanto-occipital membranes are attached to its ant. and post margins, and lig. *apicis dentis* (suspensory lig.) within its anterior margin.

Condylus occipitalis, at antero-lateral margin of for. magnum. Converges anteriorly towards its fellow; articulates with atlas. Articular surface, convex, directed downwards and laterally; may be partially subdivided; *capsula articularis* is attached to its circumference. *Tubercle for alar* (check) *ligament* is on medial margin of condyle. *Hypoglossal canal* (ant. condyloid foramen) is above and lateral to anterior end of condyle; *transmits* hypoglossal n., meningeal branch of asc. pharyngeal art.; veins connecting veins of medulla with pharyngeal plexus; meningeal lymphatics passing to deep cervical glands. *Condyloid fossa* is posterior to condyle. *Condyloid canal*, often absent, leads from fossa into groove for transverse (lateral) sinus, from which it transmits an emissary vein to deep veins at back of neck.

Processus jugularis, lateral to condyle, articulates laterally, by synchondrosis, with petrous temporal; inferior surface is rough for insertion of rectus lateralis. *Incisura jugularis* (*jugular notch*), on anterior border, forms post. margin of jugular foramen.

Planum nuchale extends from for. magnum to occipital protuberance and superior nuchal lines; displays occipital crest and inferior nuchal line—see p. 41.

Postero-lateral Area. — **Bone**: temporal. **Fissures**: f. speno-petrosa, petro-occipitalis, petro-tympanica. **Suture**: s. occipito-mastoidea. **Foramen lacerum**, *bounded* by petrous temporal, basi-occipital, body and great wing of sphenoid; *filled* below with fibro-cartilage; *occupied* by internal carotid artery with plexuses of veins and sympathetic nerves; *crossed* by deep and greater superficial petrosal nerves, which unite to form nerve of pterygoid canal (Vidian); *traversed* vertically by small veins connecting cavernous sinus and pharyngeal plexus, meningeal branches of ascending pharyngeal artery; meningeal lymphatics passing to upper deep cervical glands. **Sulcus tubæ auditivæ** lodges cartilaginous part of auditory (Eustachian) tube. Extends laterally and posteriorly, between great wing of sphenoid and petrous temporal, from pterygoid tubercle to musculo-tubal canal at medial side of angular spine of sphenoid. **Canalis musculo-**

tubarius, in substance of temporal bone, between petrous and tympanic plate, opens by postero-lateral end into tympanum, is divided by septum (*processus cochleariformis*) into *semicanalis m. tensoris tympani* above and *semicanalis tube auditivæ* below.

Tuberculum articulare (*eminentia articularis*), smooth, convex, is lateral to angular spine, continuous with ant. root of zygoma; *fossa mandibularis* lies posterior to it. Both articulate with head of mandible, articular disc intervening; and capsula articularis is attached around their circumference. *Post-glenoid tubercle* lies behind fossa, in front of acoustic meatus.

Petro-tympanic fissure (*Glaserian*) extends from anterior margin of acoustic meatus, behind mandibular fossa, to sulcus tube; *transmits* tympanic branch of mid. meningeal art., *lodges* anterior process of malleus. At its medial end is the opening for chorda tympani (canal of Huguier). **Pars tympanica** (**tympanic plate**), posterior to and below petro-tympanic fissure, forms anterior and lower walls, and part of posterior wall of ext. acoustic meatus, and with mandibular fossa forms *glenoid fossa*, in which part of parotid is lodged, and sheath of parotid is attached to its margins. *Upper border* sinks into petro-tympanic fissure; *lateral* forms *auditory process*, to which cartilage of ear is attached; *medial* fuses with petrous; *lower* partly ensheathes **processus styloideus**, which projects downwards, anteriorly and medially, and gives origin to stylo-pharyngeus, stylo-hyoideus, styloglossus, stylo-mandibular and stylo-hyoid ligaments.

Stylo-mastoid foramen, posterior to styloid process; *transmits* facial n., and stylo-mastoid branches of post. auricular vessels. It is the lower end of *canal for facial nerve*. *Incisura mastoidea* (*digastric fossa*), posterior to stylo-mastoid foramen, on medial side of mastoid process, gives origin to post. belly of digastric. To its medial side, near occipito-mastoid suture, is the *groove for occipital artery*.

Jugular foramen lies between petrous temporal and jugular process of occipital, medial to styloid process. It *transmits* inferior petrosal sinus, antero-medially; transverse sinus becoming jugular vein, postero-laterally; between these, glosso-pharyngeal, vagus and accessory nerves, in that order from before backwards; meningeal branches of occipital and ascending pharyngeal arteries; meningeal lymphatics

passing to deep cervical glands. *Fossa jugularis* forms antero-lateral boundary of foramen; on its lateral wall is a foramen which auricular branch of vagus enters.

Carotid canal, in petrous temporal, anterior to jugular foramen; *transmits* int. carotid art. with plexus of sympathetic nerves from sup. cervical ganglion; small veins connecting cavernous sinus with pharyngeal plexus; meningeal lymphatics passing to deep cervical glands. On ridge between jugular foramen and carotid canal is a foramen which tympanic branch of glosso-pharyngeal enters. Rough quadrilateral area on under surface of petrous, between carotid canal and for. lacerum, gives origin to levator veli palatini.

BASIS CRANII INTERNA

Fossa Cranii Anterior.—**Bones:** squama and pars orbitalis of frontal; crista galli and lamina cribrosa of ethmoid; small wings and adjoining part of body of sphenoid. **Sutures:** those between these bones.

Median Part.—*Crista galli* stands up in middle; divides anteriorly into *processus alares*; gives attachment to falx cerebri. *Crista frontalis*, on cerebral surface of frontal, gives attachment to falx cerebri; divides above to form margins of sagittal sulcus for superior sagittal sinus (sup. longitudinal). *Foramen cecum*, at lower end of crest, between frontal and crista galli, transmits emissary vein connecting commencement of sup. sagittal sinus with veins of nasal cavity, or with angular vein.

Nasal slit, at the side of alar process of crista galli, *transmits* anterior ethmoidal nerve to interior of nose, where it becomes internal nasal n. *Olfactory foramina* in lamina cribrosa transmit olfactory nerves, with sheaths of dura mater and small vessels. *Ethmoidal foramina*, from orbit, open at side of lamina cribrosa, from between orbital part of frontal and ethmoidal labyrinth. Olfactory tract and bulb lie on groove on body of sphenoid and lamina cribrosa. *Ethmoidal spine* projects from ant. border of upper surface of sphenoid to articulate with post. edges of laminae cribrosae.

Lateral part shows marks for gyri and sulci of frontal lobe, and grooves for ant. meningeal vessels. Orbital part of frontal bone roofs in orbit and ethmoidal air cells, and encloses part of frontal sinus. Posterior margin, formed by small wing, is free and overhanging, projects into fissura

lateralis cerebri (Sylvius), ends medially as *anterior clinoid process*, to which end of free edge of tentorium cerebelli is attached.

Fossa Cranii Media.—**Bones:** sphenoid, petrous and squamous temporals, sphenoidal angle of parietal. **Sutures:** between adjacent bones. **Fissure:** f. spheno-petrosa between great wing of sphenoid and petrous temporal.

Median Part.—*Sulcus chiasmatis*, in front, leads laterally to *optic foramina*. Posterior to it, is *sella turcica*, consisting of (1) *tuberculum sellæ* (olivary eminence), an oval eminence in front; (2) *fossa hypophysæos* (pituitary fossa, a smooth median depression for hypophysis (pituitary body); and (3) *dorsum sellæ*, an upstanding quadrilateral plate, whose upper angles are called *posterior clinoid processes* and give attachment to ends of attached margin of tentorium; base of dorsum is grooved at side by passage forwards of abducent nerve. *Middle clinoid process* is a little tubercle postero-lateral to tuberculum sellæ on each side, sometimes large enough to unite with anterior or posterior clinoid process, or both.

Lateral Part. *Sulcus caroticus*, for int. carotid art., along the side of body of sphenoid, ends anteriorly between anterior and middle clinoid processes, and posteriorly at *foramen lacerum* (p. 44), where it is bounded postero-medially by *petrosal process* of sphenoid, which articulates with apex of petrous temporal, and antero-laterally by *lingula sphenoidalis*. *Pterygoid canal* (Vidian) is found on anterior margin of for. lacerum, below lingula. *Superior orbital fissure* (p. 37) is in anterior wall of lateral part of fossa, between body and wings of sphenoid, and may be completed supero-laterally by frontal. *For. rotundum* (p. 40) is below and posterior to medial end of sup. orbital fissure. *For. ovale* (p. 43) is near posterior edge of great wing, $\frac{1}{2}$ inch postero-lateral to rotundum. *For. spinosum* (p. 43) is postero-lateral to ovale at posterior angle of great wing. *Groove for middle meningeal artery and vein* leads laterally and anteriorly from f. spinosum over squamous temporal, over position of tuberculum articulare on inferior surface; divides at variable point for anterior and posterior branches of artery. *Anterior groove* runs anteriorly and upwards to sphenoidal angle of parietal, sometimes tunnelling it, and turns upwards and posteriorly over parietal; *posterior groove* runs upwards and posteriorly, and passes on to parietal by crossing its inferior

border near its middle. *Eminentia arcuata*, at upper part of middle of ant. surface of petrous temporal, is produced by superior semicircular canal of ear. Lateral to it the *tegmen tympani* extends downwards and antero-medially, forming roof of tympanic antrum and cavity, and musculotubal canal. Below and medial to arcuate eminence is *hiatus canalis facialis* (hiatus Fallopii), a slit transmitting greater superficial petrosal nerve and petrosal branch of mid. meningeal art. *Sulcus n. petrosi superficialis majoris* leads downwards and medially from hiatus to for. lacerum. Below this groove is *sulcus n. petrosi superficialis minoris*. *Impressio trigemini* for trigeminal nerve and semilunar ganglion (Gasserian) is near apex of petrous temporal. Its floor is roof of inner end of carotid canal, and is often deficient.

Fossa Cranii Posterior.—**Bones:** body of sphenoid, occipital, petrous and mastoid temporal, mastoid angle of parietal. **Sutures:** s. occipito-mastoidea, parieto-mastoidea. **Fissure:** f. petro-occipitalis.

Clivus extends from dorsum sellæ to for. magnum, presents broad median groove on which medulla oblongata, pons and basilar artery lie, and to which membrana tectoria is attached, in front of for. magnum; while laterally *sulcus petrosus inferior*, for inf. petrosal sinus, runs to *jugular foramen* (p. 45), along junction of occipital and petrous, grooving both. Internal end of *hypoglossal canal* (p. 44) is on antero-lateral margin of *foramen magnum* (p. 43). *Tuberculum jugulare* is a smooth eminence above and anterior to hypoglossal canal, and is grooved posteriorly by glossopharyngeal, vagus and accessory nerves as they pass to jugular foramen. *Internal occipital protuberance* is centre of *eminentia cruciata*. From it ridges run up, down and laterally. *Internal occipital crest*, running downwards from it to for. magnum, is occasionally cleft at lower end by *fossa vermiciformis*, and gives attachment to falx cerebelli, in base of which lies occipital sinus. On each side of crest is the *cerebellar fossa*. Groove for transverse (lateral) sinus extends laterally from protuberance to lateral angle of occipital, across mastoid angle of parietal, then downwards and medially on mastoid temporal, and forwards over jugular process of occipital to jugular foramen. From protuberance to upper end of mastoid it is called *sulcus transversus*, and tentorium cerebelli is attached to its lips. S-shaped part on mastoid temporal and jugular

process is called *sulcus sigmoideus*. *Mastoid foramen* (p. 45) opens into it, on mastoid; and *condyloid canal* (p. 44), when present, opens on jugular process. *Notch for trigeminal nerve* is on upper border of petrous temporal, near apex. *Sulcus petrosus superior* for sup. petrosal sinus lies along this upper border; tentorium is attached to its lips. *Meatus acusticus internus*, on post. surface of petrous temporal, *transmits* both roots of facial n., acoustic (auditory) n., internal auditory vessels. At its bottom is the upper or proximal end of canalis facialis (aqueduct of Fallopius).

Apertura externa aquæductus vestibuli lies in a slit overhung by a lip of bone, $\frac{1}{2}$ inch lateral to meatus. It lodges sacculus endolymphaticus and transmits small artery and vein. **Fossa sub arcuata**, a depression above and between meatus and aqueduct, lodges a process of dura, transmits small vessels. **Apertura externa canaliculi cochleæ** (aqueduct of cochlea), in a depression on ant. margin of jugular foramen directly below meatus, lodges a process of dura, transmits small vein from cochlea to internal jugular vein.

CEREBRAL SURFACE OF VAULT OF CRANIUM

Bones.—Frontal above superciliary arches; occipital above protuberance; parietal except sphenoidal and mastoid angles; upper edge of squamous temporal.

Sutures. Coronal, sagittal, lambdoid, squamous.

Crista frontalis is in median plane anteriorly. **Sulcus sagittalis** for superior sagittal sinus (sup. longitudinal) begins on frontal crest, runs upwards and posteriorly on frontal, along parietals at their suture, to apex of occipital; descends upon upper ridge of eminentia cruciata to internal protuberance, where it joins sulcus transversus of right side usually. **Falx cerebri** is attached to its lips. **Foveolæ granulares** are pits for arachnoideal granulations (Pacchionian bodies), found in old skulls, at sides of sagittal groove on frontal and parietal. **Impressiones digitatæ** are marks produced by gyri of cerebrum all over skull. **Sulci arteriosi** are grooves for meningeal vessels, best marked on parietal. Groove for ant. branch of mid. meningeal overlies anterior central gyrus (Rolandic area) of brain.

SAGITTAL SECTION OF SKULL

Made on one side of median plane to show lateral wall of nasal cavity on one side and septum on the other.

Cavum Nasi.—**Roof:** *Sloping anterior part:* nasal bone, pars nasalis of frontal. *Horizontal middle part:* lamina cribrosa of ethmoid. *Sloping posterior part:* (1) sphenoidal conchæ (turbinates)—curved plates of bone fused to anterior and under surfaces of sphenoid, pierced by opening of sphenoidal sinus; (2) body of sphenoid, (3) ala of vomer, (4) sphenoidal process of palatine, (5) vaginal process of medial pterygoid lamina. **Floor:** horizontal part of palatine, palatine process of maxilla. **Lateral wall:** nasal bone, medial surfaces of frontal process and body of maxilla, lacrimal, labyrinth of ethmoid, perpendicular part of palatine, medial pterygoid lamina. Nasal conchæ (turbinated bones), superior and middle, project medially from labyrinth; inferior is separate and projects medially from its articulation with maxilla, lacrimal, ethmoid and palatine. Spaces below and lateral to conchæ are the *meatus nasi, superior, medius* and *inferior*. On lateral wall of middle meatus is a rounded eminence called *bullæ ethmoidalis*, below which is a curved groove called *hiatus semilunaris*. **Medial wall or septum nasi osseum:** perpendicular plate of ethmoid above, vomer posteriorly and below; supplemented by (1) nasal crest, which is formed by articulating margins of nasal bones; (2) spina frontalis of frontal; (3) crista sphenoidalis on anterior surface of sphenoid; (4) nasal crest, which is formed by upturned edges of palatine and maxillæ where they articulate with their fellows.

Communications.—*Naso-lacrimal canal*, from orbit, opens into inferior meatus. *Foramina of Scarpa and of Stenson* (p. 42) lead down into mouth from anterior part of floor. *For. sphenopalatinum* (p. 40) opens into pterygo-palatine fossa from upper and back part, just above posterior end of middle concha. *Maxillary sinus* occupies body of maxilla and its walls correspond to surfaces of maxilla. Its floor corresponds to alveolar margin, and its deepest part is opposite 1st molar and 2nd premolar teeth. Large opening in medial wall is covered by inferior concha, lacrimal, perpendicular part of palatine, uncinate process of ethmoid. They leave one or two small orifices opening into hiatus semilunaris in middle meatus. *Frontal sinus*, in frontal bone above root of nose, extends laterally under superciliary arches and into orbital plate; is separated from its fellow by a septum. Sinus measures $1\frac{1}{4}$ inches in height from fronto-maxillary suture, 1 inch broad from median plane, $\frac{3}{4}$ inch in

depth ; but varies greatly in size ; opens by passage through ethmoid, called *infundibulum*, into hiatus semilunaris. *Cellule ethmoidales*, air-cells or sinuses in labyrinth, divided into groups : *anterior* open into h. semilunaris ; *middle*, on surface of bulla ethmoidalis ; *posterior*, into superior meatus. *Sphenoidal sinus*, in body of sphenoid, separated from its fellow by a septum, opens into *recessus sphenoidalis*, the small interval above superior concha. Sinus in orbital process of palatine communicates with sphenoidal or posterior ethmoidal sinuses.

Relations. — *Above* : frontal and sphenoidal sinuses, anterior and middle cranial fossæ. *Below* : mouth. *Laterally* : maxillary sinus, ethmoidal air-cells, orbit, pterygoid, pterygo-palatine and infra-temporal fossæ. *Posteriorly*, it opens into nasal pharynx by choana, and *anteriorly* on to the face by apertura piriformis.

BONES OF SUPERIOR EXTREMITY

SHOULDER GIRDLE—CLAVICLE AND SCAPULA

Clavicula. Lies nearly horizontally on anterior aspect of upper part of thorax ; palpable in its whole length. Curved like italic letter *f* ; medial half convex forwards ; lateral half convex backwards, and flattened from above downwards.

Sternal end can be felt overriding sternum. Rough above ; smooth below for articulation with sternum and 1st costal cartilage, articular disc intervening. **Acromial end** : flattened ; facet on lateral edge looks laterally and downwards, and articulates with acromion of scapula, articular disc intervening.

Shaft.—Medial $\frac{2}{3}$ prismatic ; lateral $\frac{1}{3}$ flattened. **Medial two-thirds** : *Surfaces* : (1) *anterior*, convex and rough ; (2) *posterior*, concave and smooth ; (3) *inferior* presents rough *costal tuberosity* medially, and longitudinal *groove for subclavius* laterally. *Borders* : superior, anterior, posterior. In a well-formed clavicle there are 4 surfaces in medial $\frac{2}{3}$, the upper part of anterior surface making a distinct *superior* surface. **Lateral third** : *Surfaces* : (1) *superior*, subcutaneous in middle ; roughened anteriorly and posteriorly by attachments of trapezius and deltoid muscles ; (2) *inferior* presents,

near posterior border, the *coracoid tuberosity*, from which *trapezoid ridge* runs forwards and laterally. *Borders*: (1) *posterior*, convex; (2) *anterior*, concave, rough, and may present tubercle, called *deltoid tubercle*. Borders are continuous with ant. and post. surfaces of medial $\frac{2}{3}$. *Nutrient foramen* is on post. aspect, and directed laterally.

Ossification.—2 primary centres at 5th or 6th week—first in body to appear,—and they soon fuse. Epiphyseal centre for *sternal end* at 20th year, fused at 25. Epiphyseal line is intra-capsular.

Attachments.—Interclavicular lig. and articular disc to rough part of **sternal end**; articular capsule to margins of smooth part. Sterno-hyoid and sometimes sterno-thyroid from medial part of **post. surface**. Sterno-mastoid from upper medial part of **ant. surface**, pectoralis major from lower part.

Costo-clavicular lig. to **costal tuberosity**. Subclavius to **groove for subclavius**, and costo-coracoid membrane to its lips. Deltoid from **ant. border of lateral $\frac{1}{3}$** , and trapezius to **post. border**, both encroaching on **upper surface**. Conoid lig. to **coracoid tuberosity**. Trapezoid lig. to **trapezoid ridge**. Articular capsule to margins of facet on **acromial end**. Deep fascia covering muscles is attached at margins of muscular attachments, and deep fascia of roof of posterior triangle of neck is attached, in two layers, to upper and lower margins of post. aspect of middle third.

Relations.—Clavicle forms the boundary between neck and front of chest and of upper limb. Anterior, middle and posterior supra-clavicular branches of 3rd and 4th cervical nerves descend *superficial* to medial, intermediate and lateral thirds, respectively, to supply skin over pectoralis and deltoid. Platysma lies superficial to these, over the lateral $\frac{2}{3}$. A few lymph glands lie in hollow below clavicle between pectoralis and deltoid. *Posterior* to medial inch or so of clavicle are sterno-hyoid, sterno-thyroid, innominate vein, phrenic nerve and int. mammary artery, pleura, lung, from before backwards. More laterally, the nerve to subclavius, ext. jugular and subclavian veins, scalenus anterior, and 1st rib are behind. More laterally still, about its middle third, the transversa scapulae (supra-scapular) vessels run nearly horizontally posterior to it, and farther back are the omo-hyoid, the third part of subclavian artery, brachial plexus, and 1st digitation of serratus anterior. Trapezins occupies lateral $\frac{1}{3}$ of posterior aspect. *Beneath* the clavicle are the costo-clavicular lig., subclavius and costo-coracoid membrane, coraco-clavicular lig., which are all attached to it. Besides these, from sternal to acromial end, there are (1) first cartilage; (2) anterior end of first rib; (3) axillary vein; (4) axillary artery; (5) brachial plexus; (6) coracoid process; (7) coraco-acromial lig., supra-spinatus and shoulder-joint.

Scapula.—Lies on postero-lateral aspect of thorax, opposite 2nd to 7th ribs. Flat and triangular, and has triangular spine projecting from dorsal surface, bent coracoid process projecting from upper border, and flat acromion continuous with apex of spine.

Margins.—(1) *Superior*, the shortest. At its lateral part is the *incisura scapularis* (supra-scapular notch); sup. transverse lig. converts it into foramen which transmits supra-scapular nerve. (2) *Vertebral* or postero-medial, the longest. (3) *Axillary* or antero-lateral, the thickest, presents rough *infra-glenoid tubercle* at its upper end. **Angles:** (1) *Medial*, obtuse; between superior and vertebral margins. (2) *Inferior*, acute; between vertebral and axillary margins; easily felt; lies opposite 7th thoracic spine. (3) *Lateral*, between sup. and axillary margins; forms *head* and *neck* of scapula. *Glenoid cavity* is a smooth concave cavity on head; piriform in shape, apex upwards; looks laterally, upwards and anteriorly; articulates with head of humerus; slight roughness above apex is called *supra-glenoid tubercle*.

Dorsal surface is unequally subdivided by spine into small *supra-spinous* and large *infra-spinous fossa*, which include also the upper and lower surfaces of spine. Oval elevated area over inferior angle is for origins of teres major and latissimus dorsi. Elongated elevated area along axillary margin is for origin of teres minor; transverse groove (or grooves) on that area is for art. circumflexa scapulæ (dorsalis scapulæ). **Costal surface** is hollowed out to form *subscapular fossa*, deepest opposite spine. Flat areas at medial and inferior angles and strip along vertebral margin are for insertion of serratus anterior (magnus).

Processus coracoideus projects from upper margin of neck. Vertical portion or *root* has posterior and anterior surfaces, lateral and medial borders; medial border bounds scapular notch laterally. *Horizontal portion* projects forwards and laterally, has upper and lower surfaces, lateral and medial borders, and its tip can be felt behind anterior margin of deltoid, 1 inch below junction of middle and lateral thirds of clavicle.

Spina scapulæ extends from vertebral margin, laterally and upwards, to neck. *Root of spine* is at vertebral margin, is smooth for bursa under trapezius, and lies opposite 3rd thoracic spine. *Upper and lower surfaces* help to form supra- and infra-spinous fossæ. *Ventral border* is attached

to upper part of dorsal surface of scapula. *Dorsal border* is subcutaneous, rough, easily felt; has upper and lower lips, with a tubercle on lower lip. *Lateral border*, smooth, rounded, forms, with the neck of scapula, the *great scapular notch*, which is bridged across by inferior transverse lig. (spino-glenoid), under which the supra-scapular nerve and transverse scapular vessels (supra-scapular) descend to infra-spinatus.

Acromion, flattened from above downwards, extends laterally and anteriorly from apex of spine. *Lateral border*, long and convex, has prominent *angle* near posterior end, used as a measuring point. Short *medial border* has a facet near tip, which slopes downwards and medially and articulates with clavicle. *Superior surface*, subcutaneous, forms top of shoulder. *Inferior surface* is smooth and is separated from supra-spinatus by sub-acromial bursa.

Nutrient foramina here and there; largest near attached border of spine.

Ossification.—Primary centre at 8th week. Epiphyseal centres: 1 for horizontal part of coracoid at first year, fuses at puberty. 1 for lateral part of coracoid and upper part of glenoid at 10, fuses at puberty; its epiphyseal line is partly intra- and partly extra-capsular. **2 or more for acromion at puberty, fused at 25; may remain separate.** 1 for inferior angle and 1 for vertebral border at puberty, fuse 20-25. 1 for lower edge of glenoid at puberty, fuses 18-20.

Attachments.—Superior transverse lig. to margins of **scapular notch**. Post. belly of omo-hyoid from ligament and adjoining lateral part of **upper margin**. Levator scapulae to **vertebral margin** above root of spine, rhomboideus minor opposite root, rh. major below root. Long head of triceps from **infra-glenoid tubercle**. Long head of biceps from **supra-glenoid tubercle**. Labrum glenoidale (glenoid lig.) and capsular lig. to circumference of **glenoid cavity**. Supra-spinatus from medial $\frac{2}{3}$ of **supra-spinous fossa**. Infra-spinatus from **infra-spinous fossa**, excepting (1) near neck, (2) oval area at inf. angle for teres major, (3) elongated area along axillary margin for teres minor. Subscapularis from **costal surface**, including ridge and elongated hollow adjoining axillary margin, but excluding (1) part near neck and (2) areas at medial and lower angles and strip along vertebral margin for serratus anterior.

Superior transverse lig. to medial margin of **root of coracoid**, coraco-humeral lig. to lateral margin. Coraco-brachialis medially and short head of biceps laterally, from tip of **horizontal part of coracoid**; pectoralis minor to medial margin and upper surface of distal half, costo-coracoid membrane to proximal $\frac{1}{2}$ of medial

margin; coraco-acromial lig. to lateral margin; coraco-clavicular lig. to upper surface. Deltoid from lower lip of *dorsal border* of **spine** and lateral border of **acromion**; trapezius to medial border of acromion, upper lip of spine, and tubercle on lower lip. Capsular lig. to circumference of *facet* on acromion. Inferior transverse lig. (spino-glenoid) to spine and neck, across great scapular notch.

Humerus.—**Proximal end** is the large, globular end. **Caput (head)**, large, convex, smooth, nearly hemispherical; directed medially, upwards and posteriorly; articulates with glenoid cavity of scapula. **Collum anatomicum (anatomical neck)** is the constriction between the head and tubercles. **Tuberculum majus** (great tuberosity) is the prominence situated laterally; forms most laterally projecting part of shoulder or "point of shoulder"; bears three impressions for muscles on superior and posterior aspects; anterior margin forms lateral lip of intertubercular sulcus; smooth lateral surface, covered by deltoid and bursa, is directly continuous with shaft. **Tuberculum minus** (small tuberosity), placed anteriorly; may be felt 1 inch lateral to and a little distal to coracoid. **Sulcus intertubercularis** (bicipital groove), between the tubercles, extends distally on to surgical neck and shaft; lodges long tendon of biceps and its mucous synovial sheath, and a branch of ant. circumflex art. **Collum chirurgicum (surgical neck)** is the region just distal to head and tubercles.

Distal End. Compressed antero-posteriorly and bent forwards. **Articular part:** 1. **Capitulum**, situated laterally, on anterior and distal aspects; smooth, convex; articulates with radius. 2. **Trochlea**, placed medially on anterior, distal and posterior aspects; pulley-shaped; medial lip more prominent, lateral lip united to capitulum by shallow groove; articulates with ulna. **Non-articular part:** 1. **Epicondylus lateralis**, lateral to capitulum; impressions on anterior and distal aspects for muscles and ligaments; posterior aspect is broad, smooth, felt subcutaneously proximal to back of elbow; is separated by grooves from trochlea medially, capitulum distally. 2. **Epicondylus medialis**, large and projecting, easily felt proximal to medial side of elbow; rough on ant. and distal aspects for muscles and ligaments; post. aspect is smooth, and presents *sulcus nervi ulnaris*, in which ulnar nerve may be felt and rolled by the finger. 3. **Fossa radialis**, proximal to capitulum, for head of radius during flexion. 4. **Fossa coronoidea**, proximal to trochlea anteriorly, for coronoid process of ulna during flexion. 5. **Fossa olecrani**, proximal

to trochlea posteriorly, for olecranon during extension ; it is much larger than the other fossæ, and bone separating it from coronoid fossa is very thin.

Corpus Humeri (Shaft).—**Anterior margin** begins at greater tubercle, ends near coronoid fossa ; proximal part is the lateral lip of intertubercular sulcus, middle part forms ant. margin of deltoid tuberosity. **Medial margin** begins at lesser tubercle, ends at medial epicondyle ; forms medial lip of intertubercular sulcus, is roughened in middle for insertion of coraco-brachialis, distal part is the *medial epicondylar ridge*. **Lateral margin** begins distal to post. aspect of greater tubercle, ends at lateral epicondyle ; indistinct proximally where lateral head of triceps arises, interrupted at middle by sulcus nervi radialis (musculo-spiral groove), distal part is the prominent *lateral epicondylar ridge*. **Anterior medial surface** is between ant. and medial margins ; intertubercular sulcus on shaft forms its proximal part. **Anterior lateral surface** is between ant. and lateral margins ; ▽-shaped *deltoid tuberosity*, for insertion of deltoid, is placed proximal to its middle. **Posterior surface**, between medial and lateral margins, is occupied by origin of medial head of triceps. *Sulcus nervi radialis* (musculo-spiral groove) begins on post. surface, runs obliquely distally and anteriorly between origins of medial and lateral heads of triceps, and posterior to deltoid tuberosity, to end distal to it ; radial (musculo-spiral) nerve and profunda vessels lie in it.

Nutrient foramen, on or near middle of medial border, is directed distally. Another is often present in sulcus n. radialis (musculo-spiral groove).

Ossification.—Primary centre for shaft at 7th week. Epiphyseal centres : 1 for head shortly after birth ; 1 for greater tubercle, 2-3 yr. ; 1 for lesser tubercle, 3-5 yr. These fuse at 7 and join shaft at 25. Common epiphyseal line is intra-capsular medially, extra-capsular laterally. 1 for capitulum and lateral half of trochlea, 2-3 yr. : 1 for medial half at 12 ; 1 for lateral epicondyle at 12. These three coalesce, and join shaft at 17 ; epiphyseal line is partly intra-, partly extra-capsular. 1 for medial epicondyle at 5, uses 18-19 ; epiphyseal line is extra-capsular.

Attachments.—Capsular lig. of shoulder to anatomical neck above, but nearly $\frac{1}{2}$ inch from it below and medially ; coraco-humeral lig. to anat. neck at ant. part of greater tubercle. Supra-spinatus, infra-spinatus, teres minor to three impressions on greater tubercle, in that order antero-posteriorly. Subscapularis

to **lesser tubercle**. *Teres minor* and *subscapularis* both extend on to **surgical neck**. To **intertubercular groove**: transverse lig., attached to both tubercles, bridges across its proximal part; more distally, on shaft, *pectoralis major* to its lateral lip, *teres major* to medial lip, *latissimus dorsi* to floor. Common extensor tendon from ant. aspect of **lateral epicondyle**; from distal aspect,—**radial collateral lig.** of elbow and *supinator* anteriorly, *anconeus* posteriorly. **Ulnar collateral lig.** to distal aspect of **medial epicondyle**; common flexor tendon from distal part of ant. aspect, *pronator teres* from proximal part, extending to epicondylar ridge. Ant. lig. of elbow to proximal margins of **radial** and **coronoid fossæ** and ant. aspect of medial epicondyle. Post. lig. to margins of **olecranon fossa** on each side, across its floor proximally, and to post. aspect of lateral epicondyle. *Coracobrachialis* to middle of **medial margin of shaft**. Medial intermuscular septum to edge of **medial epicondylar ridge**, *pronator teres* from distal part of ant. aspect. Lateral head of *triceps* to proximal $\frac{1}{4}$ of **lateral margin**. Lateral intermuscular septum to edge of **lateral epicondylar ridge**; *brachio-radialis* from proximal $\frac{3}{4}$ of its ant. aspect, ext. carp. *radialis longus* from distal $\frac{1}{4}$. *Brachialis* from distal $\frac{1}{3}$ of **anterior medial** and **anterior lateral surfaces**. *Deltoid* to **deltoid tuberosity**. Medial head of *triceps* from **posterior surface**, distal to groove for radial nerve.

Ulna.—Medial bone of forearm. Proximal end large, distal end small. **Proximal end**:—**Olecranon**, placed posteriorly, projects proximally, forms prominence of elbow; proximal, lateral and medial surfaces are rough; dorsal surface is smooth, triangular and separated from skin by subcutaneous bursa; volar (anterior) surface helps to form semilunar notch (greater sigmoid cavity). **Processus coronoideus** projects anteriorly; proximal surface forms distal part of semilunar notch; volar surface rough; tubercle and ridge between volar and medial surfaces for muscles; concave *incisura radialis* (radial notch) on lateral surface articulates with head of radius. *Incisura semilunaris* (semilunar notch) formed by olecranon and coronoid, articulates with trochlea; notched at the sides, divided by vertical ridge into areas corresponding to lateral and medial parts of trochlea.

Distal End. Rounded **capitulum** (head) articulates with triangular articular disc (fibro-cartilage) distally; its lateral surface articulates with radius when arm is supine; when arm is prone the anterior surface articulates with radius, and lateral surface is seen as a knob proximal to wrist. **Processus styloideus**, placed medially and dorsally, felt as a ridge proxi-

mal to medial side of dorsum of wrist when arm is supine, is separated from dorsal surface of head by a groove occupied by ext. carpi ulnaris tendon; at its base, between it and distal surface of head, is a pit for attachment of apex of triangular articular disc.

Corpus ulnæ (shaft) tapers to distal end. *Tuberosity of ulna* is the roughness on volar surface, distal to coronoid. *Supinator crest* extends distally from back of radial notch to interosseous crest; it forms dorsal boundary of a triangular hollow, distal to radial notch. *Pronator ridge* runs obliquely over distal $\frac{1}{2}$ of volar surface. **Volar margin**, round and smooth, extends from tuberosity to styloid process. **Dorsal margin**, subcutaneous, easily felt, sinuous; extends from dorsum olecrani to styloid process. **Interosseous crest** (lateral border) extends from hollow below radial notch to near distal end; prominent proximally, indistinct distally; interosseous membrane is attached to it. **Volar surface**, between volar and interosseous borders, presents: (1) **nutrient foramen** directed towards elbow, on proximal $\frac{1}{3}$; (2) tuberosity at proximal end; (3) pronator ridge distally. **Medial surface**, between volar and dorsal margins, is subcutaneous in distal $\frac{1}{3}$ and easily felt. **Dorsal surface**, between dorsal and interosseous borders, is divided by vertical ridge into a bare, smooth *medial* part, and a *lateral* part mapped into areas for attachments of extensor muscles.

Ossification.—Primary centre at 7th week. Epiphyseal centres: 1 for top of olecranon at 10, fuses at 16; epiphyseal line may be wholly extra-capsular, or may be intra-capsular anteriorly. 1 for distal end at 6, fuses 20-23; epiphyseal line is extra-capsular.

Attachments.—**Olecranon**: triceps to posterior part of proximal end, bursa is in relation to intermediate part, posterior lig. of elbow to ant. part of prox. end and to lateral border; anconeus to lateral surface, posterior to lig.; post. band of ulnar collateral lig. of elbow to medial border, flexor carpi ulnaris and flex. profundus from medial surface. **Coronoid process**: ant. band of ulnar collateral lig., flex. sublimis, flex. pollicis longus and pronator teres from tubercle and ridge between volar and medial surfaces; ant. lig. of elbow to anterior projecting margin; brachialis to volar surface. **Radial notch**: annular (orbicular) lig. to volar and dorsal margins, lig. quadratum to distal margin. **Shaft**: brachialis and chorda obliqua (oblique lig.) to *tuberosity*. Supinator from *supinator crest* and hollow distal to radial notch. Flex. dig. profundus from proximal $\frac{3}{4}$ or $\frac{2}{3}$ of *volar* and *medial* surfaces, extending on to medial

surfaces of coronoid and olecranon. Pronator quadratus to distal $\frac{1}{2}$ of *volar surface* and to *pronator ridge*. Anconæus to proximal part of *dorsal surface* of shaft and adjoining lateral aspect of olecranon. Abductor pollicis longus, extensor poll. longus and ext. indicis proprius from lateral part of *dorsal surface*, in that order proximodistally. Interosseous membrane to *interosseous crest*. Flex. carpi ulnaris from medial side of olecranon and proximal $\frac{1}{2}$ of *dorsal border* of shaft. **Head**: articular capsule of distal radio-ulnar joint to dorsal and volar surfaces; a septum of dorsal carpal lig. (post. annular) to dorsal surface. **Styloid process**: ulnar collateral lig. of wrist to tip; apex of triangular articular disc to pit at base.

Radius.—Lateral bone of forearm, proximal end small, distal end large. **Proximal end**:—**Capitulum head**, a cup-shaped disc; concavity articulates with capitulum humeri; circumference articulates with radial notch of ulna and is embraced by lig. annulare radii orbicular, but is easily felt at back of elbow, distal to lateral epicondyle. **Collum neck** is the constricted portion supporting head. **Tuberositas radii** bipitital, placed on medial side, distal to neck; is smooth anteriorly, rough posteriorly for insertion of biceps.

Distal end, quadrilateral and bent forwards. *Volar (anterior) surface*, broad, concave, with a ridge at distal margin, felt proximal to wrist. *Lateral surface* is grooved for lodgment of tendons of abductor poll. longus and ext. poll. brevis; projects distally as the pyramidal **styloid process**, felt in hollow on radial side of wrist, at more distal level than styloid of ulna. **Incisura ulnaris ulnar notch** on *medial surface* articulates with head of ulna. *Dorsal surface*, convex, irregular; presents **dorsal tubercle** Lister's about its centre, easily felt, proximal to dorsum of wrist. On medial side of tubercle are 2 grooves: narrow oblique one lodges tendon of ext. pollicis longus; broader and more medial one lodges ext. dig. communis and indicis proprius. Broad groove on lateral side of tubercle, sometimes subdivided into two, lodges ext. carpi rad. longus and brevis. *Carpal or distal surface*, concave, presents 2 areas: lateral, triangular, extends on to styloid process, articulates with navicular; medial, quadrilateral, articulates with os lunatum (semilunar).

Corpus Radii Shaft. **Volar margin** extends from tuberosity to styloid process; distinct proximally, where it is sometimes called *ant. oblique line*; distinct again at distal end. **Dorsal margin** extends from back of tuberosity

to styloid process ; distinct only in middle $\frac{1}{3}$. **Interosseous crest** (medial margin) begins near tuberosity and ends distally by dividing into 2 lines which enclose triangular area near ulnar notch. **Volar surface**, between volar and interosseous margins, presents *nutrient foramen* on proximal $\frac{1}{3}$, directed towards elbow. **Dorsal surface**, between dorsal and interosseous margins, gives origin to muscles in proximal $\frac{2}{3}$, but in distal $\frac{1}{3}$ is only covered by tendons which groove distal end. **Lateral surface**, between volar and dorsal borders, encroaches in its proximal $\frac{1}{3}$ on volar and dorsal aspects, and presents a rough oval mark about its middle for insertion of pronator teres.

Radius is convex medially in proximal $\frac{1}{3}$, convex laterally in distal $\frac{2}{3}$. Biceps and pronator teres are inserted into maximum points of curves and their actions as supinator and pronator are thus enhanced.

Ossification. — Primary centre at 7th week. Epiphyseal centres : 1 for capitulum, 5th-7th yr., fuses 18-20 ; epiphyseal line is intra-capsular ; 1 for distal end, 2nd-3rd yr., fuses 20-25 ; epiphyseal line is extra-capsular ; 1 for tuberosity at 15 and soon fuses.

Attachments. — Distal margin of lig. annulare (orbicular) and lateral margin of lig. quadratum around **neck**, loosely. Biceps to post. part of **tuberosity** and separated from ant. part by bursa. **Shaft** : chorda obliqua just distal to tuberosity. Flex. dig. sublimis from proximal part of *volar margin*. Flex. poll. longus from proximal $\frac{2}{3}$ of *volar surface*. Pronator quadratus to distal $\frac{1}{3}$ of *volar surface and margin*, to volar surface of distal end and triangle above ulnar notch. Interosseous membrane to *interosseous crest* and to the more dorsal of the two lines into which it divides. Supinator to proximal $\frac{1}{3}$ of *lateral surface*, including its encroachments on to volar and dorsal aspects and extending proximally to neck. Pronator teres to middle of lateral surface. Abductor pollicis longus and ext. poll. brevis from *dorsal surface*. **Distal end** : volar radio-carpal lig. to distal ridge on volar surface. Radial collateral lig. of wrist to *styloid process* ; dorsal radio-carpal lig. to distal margin of dorsal surface. Base of triangular articular disc to edge between carpal surface and ulnar notch. Articular capsule of distal radio-ulnar joint to dorsal and volar margins of ulnar notch. Lateral end of dorsal carpal lig. (annular lig.) to ridge between volar and lateral surfaces, and its septa to ridges on dorsal surface. Brachio-radialis to proximal part of groove on lateral surface.

Carpus (Wrist).—Composed of 8 small bones arranged in 2 rows, and named from lateral to medial side :—

Proximal row: os naviculare (scaphoid); os lunatum (semilunar); os triquetrum (cuneiform); and os pisiforme, on volar surface of triquetrum. **Distal row:** os multangulum majus (trapezium); os multangulum minus (trapezoid); os capitatum (magnum); os hamatum (unciform). All except triquetrum and pisiform have 6 surfaces.

Carpus, looked at as a whole, has 6 surfaces. **Proximal surface:** convex, articulates with radius and triangular articular disc to form wrist joint. **Distal surface:** irregular, articulates with metacarpus. **Dorsal surface:** convex, rough for ligaments; related to extensor tendons, and laterally to radial artery. **Volar surface:** rough for ligaments and muscles; deeply concave on account of projection of tubercle of navicular and ridge on multangulum majus (trapezium) laterally, and pisiform and hook of hamatum (unciform) medially. This concavity or groove lodges flexor tendons and their sheaths and the median nerve, and is bridged across by lig. carpi transversum (ant. annular). **Radial or lateral surface:** rough for ligaments, is related to extensor tendons of thumb. **Ulnar or medial surface** is rough for ligaments and is subcutaneous.

Proximal row, looked at by itself, is convex proximally, concavo-convex distally, and its dorsal surface is smaller than the palmar. **Distal row** is concavo-convex proximally, irregular distally, and its dorsal surface is larger than palmar.

Each bone has one or more salient characters by which it can be distinguished. Triquetrum is a 3-sided pyramid, base being lateral surface. Multangulum minus is the smallest except pisiform, and has a fancied resemblance to a Chinese boot. Capitatum is the largest and is surmounted by large rounded head. Distinguishing characters of the others are italicised in accompanying table.

In order that a bone may be referred to its proper side it should be held in the position which it occupies in erect body (proximal surface directed upwards, volar surface forwards). Lateral surface (or border or end) then looks towards side to which it belongs.

[TABLE

Names and Dates of Appearance of Ossifying Centres.	Surfaces : Characters, Articulations	
	Proximal.	Lateral.
Os Naviculare (Scaphoid) . . . 5th to 7th year.	Larger convexity ; radius	<i>Tuberosity</i> felt proximal to ball of thumb ; radial collateral lig. abductor polli. brevis ; transverse lig. of carpus (ant. annular).
Os Lunatum (Semilunar) . . . 5th to 7th year.	Convex ; radius and triangular articular disc	Flat, <i>crescent facet</i> naviculare ; interosseous lig.
Os Triquetrum (Cuneiform) . . 3rd year.	Convex ; triangular articular disc	Base, flat ; lunatum
Os Pisiforme 10th to 12th year.	<i>These surfaces are confluent, mostly convex and</i> transverse lig. of carpus (ant. annular), volar lig. metacarpum ; flexor carpi ulnaris, abductor	
Os Multangulum majus (Trapezium) 5th to 7th year.	Concave ; navicular	Broad, flat, rough ; radial collateral lig.
Os Multangulum minus (Trapezoid) 5th to 7th year.	Smallest surface, concave ; navicular	Separated from distal surface by triangular roughness ; multangulum majus
Os Capitatum (Os Magnum) . . 1st year.	Convex ; lunatum	Convex proximally for navicular, flat distally for multangulum minus
Os Hamatum (Unciform) . . . 2nd year.	A border, sometimes articulating with lunatum	Flat ; capitatum

s or Names of Structures attached or related to them.

Distal.	Medial.	Volar.	Dorsal.
aller convexity ; ultangulum ma- is and minus	<i>Concavity</i> distally for capitatum, flat proximally for lun- atum	Broad, rough, con- cave ; volar radio- carpal and inter- carpal lig.	Narrow, rough ; dor- sal radio-carpal and intercarpal lig.
<i>lunar con- vity</i> ; capitatum	Flat, quadrilateral ; triquetrum	Large, convex, rough ; volar radio- carpal and inter- carpal lig.	Small, rough ; dor- sal radio-carpal and intercarpal lig.
ncavo - convex ; amatum	Apex, rough ; ulnar collateral lig. and dorsal lig. of carpus (post. annular)	Flat with circular facet medially for pisiform ; capsula articularis, volar carpal lig.	Confluent with proxi- mal surface ; dorsal radio-carpal and intercarpal lig.
<i>gh</i> ; capsula articularis ; dorsal lig. of carpus (post annular), carpus, ulnar collateral lig., lig. pisohamatum and pis- ti quinti			Flat, circular ; tri- quetrum
<i>iddle-shaped</i> ; 1st etacarpal ; sur- ounded by capsula rticularis	Large proximal area for multangulum minus, small distal area for 2nd meta- carpal	<i>Narrow groove</i> bldges tendon of flex. carpi radi. <i>ridge</i> and rough surface for trans- verse lig. of carpus, volar intercarpal and carpo-metacar- pal lig. ; adductor brevis, adductor, opponens, flexor brevis pollicis ; ridge felt through ball of thumb	Rough ; dorsal inter- carpal and carpo- metacarpal lig. radial artery crosses it
ncavo-convex or iddle shaped ; 2nd etacarpal	Concave ; capitatum	Small, rough ; volar intercarpal and carpo-metacarpal lig. ; adductor pollicis	Large, rough ; dor- sal intercarpal and carpo-metacarpal lig.
e large facet for rd metacarpal, wo smaller for 2nd nd 4th	Flat ; hamatum	Convex, rough ; volar intercarpal and carpo-metacar- pal lig., adductor pollicis	Broad, flat, rough ; dorsal intercarpal and carpo-metacar- pal lig.
ooth, divided by ntero - posterior idge into <i>two</i> <i>rets</i> for 4th and th metacarpals	Concavo-convex and sloping proximally and laterally for triquetrum, rough edge distally for ulnar collateral lig.	Rough for volar inter- carpal and carpo- metacarpal lig. Presents <i>hook</i> felt through ball of little finger, gives attach- ment to transverse lig. of carpus, lig. pisohamatum, op- ponens and flexor digiti quinti brevis	Broad, rough ; dor- sal intercarpal and carpo-metacarpal lig.

Metacarpus forms skeleton of palm ; consists of 5 bones, numbered 1 to 5 from radial to ulnar side. Each has (1) proximal end or base, which articulates with carpus ; (2) a body or shaft ; (3) distal end or head, which articulates with 1st phalanx. Heads of metacarpals form the proximal row of knuckles.

In medial four (2-5) : Capitulum (head) : convex, smooth on distal and volar aspects, for articulation with phalanx and with volar accessory lig., which is attached on proximal side of head ; rough at sides for lig. collateralia. **Corpus (shaft) :** curved longitudinally, with palmar concavity. Prismatic on transverse section—dorsal, lateral and medial surfaces. 2nd, 3rd, 4th each give origin to two dorsal interossei, 5th to one ; 2nd, 4th, 5th each give origin to one palmar interosseous. Adductor pollicis arises from 3rd ; opponens dig. quinti is inserted into ulnar side of 5th. **Basis :** bases articulate with one another and with carpus ; volar, dorsal and interosseous ligaments connect them to one another and to carpus. Adductor pollicis arises from volar surface of 2, 3 and 4, and deep palmar arch lies just distal to them. Distinguishing features are on bases. 2nd is *notched* for multangulum minus ; larger medial margin of notch articulates with capitulum, small *lateral* with multangulum majus ; extensores carpi radiales are inserted into dorsum, flexor carpi radialis into volar surface. 3rd articulates with capitulum ; has **styloid process** dorso-laterally ; ext. carpi radialis brevis inserted into dorsum at base of styloid, flex. carpi rad. into volar surface. 4th is cuboidal ; articulates with hamatum and slightly with capitulum ; double metacarpal facet is on *lateral side*. 5th, concavo-convex articular surface for hamatum, tubercle on medial side, metacarpal facet is on *lateral side* ; extensor carpi ulnaris inserted dorso-medially, lig. piso-metacarpeum on volar surface.

1st metacarpal : shorter, stouter than others ; compressed from before backwards. **Head :** elongated transversely, grooved on volar surface by sesamoid bones in adductor and flexor pollicis brevis ; collateral ligaments attached at sides, and volar accessory, proximal to head. **Shaft :** volar surface divided by ridge into larger *radial area* for opponens and smaller *ulnar area* for 1st dorsal interosseous. **Base :** *saddle-shaped* articular surface for multangulum majus, surrounded by articular capsule ; abductor poll. longus inserted into radial and volar surface of base, interosseus primus volaris arises from medial side. *Usually does not articulate with 2nd.*

To determine the side to which a metacarpal belongs hold base upwards, volar surface forwards. Lateral aspect looks to its own side.

Ossification.—Primary centre for shaft and base of 2, 3, 4, 5, in

that order, during 9th-10th week; for shaft and head of 1 a little later. Epiphyseal centre for heads of medial four and base of first, about 3rd year, fuse about 20. Epiphyseal lines are extra-capsular.

Digits are numbered 1 to 5 from radial to ulnar side and are named: pollex thumb, index forefinger, digitus medius middle finger, digitus annularis ring finger, digitus minimus or digitus quintus little finger.

Phalanges. Each finger has 3 phalanges, which diminish in size proximo-distally, and are named 1st, 2nd, 3rd. Thumb has 2, named 1st, 2nd. Each is compressed dorso-ventrally. Base of 1st phalanx is concave, head is pulley-shaped; base of 2nd has median ridge, and a hollow on each side, head is pulley-shaped; base of 3rd like that of 2nd, but head is expanded, and rough on volar surface.

First phalanx: Basis concave articulates with metacarpal, surrounded by articular capsule; volar accessory lig. is attached to volar aspect, collateral ligs., lumbrical and interosseus muscles to sides. In case of thumb extensor pollicis brevis to dorsum, adductor and deep head of flexor brevis to medial side, abductor brevis and flexor brevis to radial side. **Corpus** (shaft) dorsal surface convex, volar, concave, lodges flexor tendons, fibrous flexor sheath attached to margins. **Trochlea**, pulley shaped distal end, articulates with 2nd phalanx, surrounded by articular capsule, collateral ligaments attached to sides; volar accessory lig. proximal to volar surface. **Second phalanx:** **Basis** has median ridge to conform to trochlea of 1st, median slip of extensor tendon attached to dorsum, capsular articulars surrounds base lig. collateral attached to sides and accessory lig. to volar surface. **Shaft and trochlea** like 1st, but flexor sublimis is inserted into margins of shaft. **Third phalanx:** **Basis** like that of 2nd, but flexor profundus is inserted into distal side articulations of extensor into dorsum. **Shaft** flat and rough on volar surface. **Tuberculus unguitractor** flat expanded distal end rough on volar surface. *Second thumb* resembles third of finger, flexor pollic. longus is inserted into volar surface of base, ext. b. long. into dorsum.

Ossification—Primary centre at 6th week. Epiphyseal centre for base in 3rd year, fuses 18-20. Epiphyseal lines are extra-capsular.

Ossa Sesamoidea—Two small nodules embedded in tendons inserted into 1st phalanx of thumb and taking the place of volar accessory ligament of metacarpophalangeal joint of thumb, groove volar surface of head of 1st metacarpal, with which they articulate.

BONES OF INFERIOR EXTREMITY

PELVIC GIRDLE HIP BONE

Os Coxæ (Hip Bone; Innominate Bone). - 3 parts : ilium, ischium, pubis, welded together at hemispherical cavity called **acetabulum**. Ilium : superior, large, expanded ; ischium : postero-inferior, short, stout ; pubis : antero-inferior, more slender. Ischium and pubis enclose **foramen obturatum**, below and anterior to acetabulum ; ilium and ischium bound the **greater sciatic notch**, posterior to acetabulum.

Os Ilium. - Expanded, flattened, fluted. Lower end is fused with ischium and pubis, and forms rather less than $\frac{2}{5}$ of acetabulum. **Crista iliaca (iliac crest)** is the long *f*-shaped upper border (or end), felt at lower limit of waist. Its margins are called *external* and *internal lips*, and interval between them is called *linea intermedia*. It ends anteriorly as **anterior superior iliac spine**, which is readily felt ; and posteriorly as **posterior superior iliac spine**, position of which is indicated by depression on skin, opposite 2nd sacral spine. *Tubercle of crest* is the prominence on external lip, felt about $2\frac{1}{2}$ inches behind anterior superior spine, and forms highest point on crest in living body, *as seen from the front*.

Anterior border extends from ant. sup. spine to margin of acetabulum, at *eminentia ilio-pectinea*, which marks junction between ilium and pubis. *Anterior inferior iliac spine* is the prominence on anterior border a little above acetabulum ; ilio-psoas leaves abdomen through notch between it and ilio-pectineal eminence. **Posterior border** extends from post. sup. spine to upper part of anterior margin of greater sciatic notch. *Posterior inferior iliac spine* is the prominence just above notch, at post. part of sacro-iliac joint, $\frac{1}{2}$ inch below posterior superior spine.

Dorsal or lateral surface (dorsum ilii), concavo-convex, subdivided into areas for gluteal muscles by 3 gluteal lines, which converge upon greater sciatic notch : (1) *Linea glutea inferior* extends from above ant. inf. spine to deepest part of sciatic notch, rough groove below it, above acetabulum, is for reflected head of rectus femoris and capsule of hip-joint. (2) *L. glutea anterior* extends from $1\frac{1}{2}$ inches behind ant. sup. spine towards sciatic notch. (3) *L. glutea posterior* extends from $3\frac{1}{2}$ inches in front of post. sup. spine towards sciatic

notch. **Medial surface** is divided into large, concave *fossa iliaca* anteriorly, and smaller *sacro-pelvic portion* posteriorly. Sacro pelvic portion is divided into three : (1) *Iliac tuberosity* is the rough upper part. (2) Middle part is the *auricular surface* for articulation with sacrum ; its posterior end corresponds to post. sup. iliac spine. (3) Lowest part helps to form side wall of pelvis minor. Ridge between iliac fossa and sacro-pelvic portion forms anterior margins of iliac tuberosity and auricular surface, and extends to ilio-pectineal eminence as *linea arcuata*, which forms the side of superior aperture of pelvis minor.

Os Ischium. **Upper end** is fused with ilium and pubis, and forms rather more than $\frac{2}{3}$ of acetabulum. In sitting posture the body rests on **lower end**. *Tuber ischiadicum* (*ischial tuberosity*) is the roughness on lower end and on lower part of dorsal surface. **Posterior border** is continuous with post. border of ilium ; *spina ischiatica* (*ischial spine*) projects medially and dorsally from about its middle. **Incisura ischiadica major** (**greater sciatic notch**) is on post. borders of ilium and ischium between post. inf. iliac spine and ischial spine. **Incisura ischiadica minor** (**lesser sciatic notch**) is between ischial spine and tuberosity. Sciatic notches are converted into foramina by lg. sacro-spinosum and sacro-tuberosum (small and great sacro sciatic lig.). **Anterior border** helps to bound obturate foramen. **Lateral border** is interrupted by notch lodging obturator externus, between acetabulum and ischial tuber. **Dorsal surface** supports piriformis, obturator internus, gemelli, and sciatic nerve ; is encroached on by ischial tuber below ; is continuous with dorsum ili above, the junction being marked by transverse ridge or fullness on dorsum of acetabulum. **Femoral surface** looks towards thigh, and is covered by obturator externus. **Pelvic surface** is continuous with pelvic surface of ilium, and forms a large part of bony side wall of pelvis minor. **Ramus** (*inferior ossis ischii*) projects ventrally and medially from lower end, and joins inf. ramus of pubis to form the "conjoined rami."

In B.N.A. the part of ischium forming acetabulum is called *capitulum*, and part extending from it to lower end, the *corpus ischiacum*.

Os Pubis. - **The body** is the expanded medial part ; **inferior ramus** runs downwards and laterally from it to meet ramus of ischium ; **superior ramus** runs upwards and laterally,

expands to join ilium and ischium and to form $\frac{1}{2}$ of acetabulum. *Ilio-pectineal eminence* marks junction with ilium; junction with ischium, at medial side of acetabular notch, is not clearly defined.

Corpus Oss. Pubis. Pelvic surface looks more upwards than backwards, is smooth, and is in relation to retro-pubic pad of fat and the bladder. **Femoral surface** is rough. **Symphyseal surface** is joined to its fellow by fibro-cartilage and ligaments of symphysis pubis. *Lateral border* helps to bound obturate foramen. **Crest of pubis** is the thick upper border of body, raised and bent forwards and downwards; easily felt at lower limit of abdomen, at side of median plane. **Pubic tubercle** (spine of pubis) is lateral end of crest, felt about 1 inch from median plane in male, a little farther away in female. When hip-bone is held in proper position, pubic tubercle and ant. sup. iliac spine are in the same vertical plane. **Angulus pubis** is angle between symphyseal surface and medial end of crest.

Ramus Superior Oss. Pubis.—**Pecten** (superior border or pectineal line) extends from pubic tubercle to ilio-pectineal eminence, to become continuous there with linea arcuata of ilium. Pecten and linea arcuata constitute the **ilio-pectineal line**. **Obturator crest** (anterior border) extends from pubic tubercle to acetabular notch. **Inferior border**, seen best from pelvic aspect, forms upper margin of obturate foramen. **Superior or pectineal surface** is the triangular area between pubic crest and ilio-pectineal eminence, and gives origin to pectineus. **Pelvic surface** is smooth and continuous with pelvic surface of body. **Inferior surface** is the *sulcus obturatorius* at upper part of obturate foramen: obturator vessels and nerve pass out of pelvis through it.

Conjoined Rami of Ischium and Pubis.—**Supero-lateral border** completes obturate foramen. **Infero-lateral border** forms margin of pubic arch. **Femoral surface** is rough for muscles. Broad shallow groove on infero-medial part of pelvic surface lodges crus of penis or of clitoris.

Acetabulum.—Directed downwards, laterally and anteriorly, articulates with femur. Horse-shoe shaped area, coated with cartilage, occupies anterior, upper and posterior parts of cup, leaving rough **fossa acetabuli** in floor, adjoining **incisura acetabuli** (acetabular notch)—the gap in lower part of cup, above obturate foramen. Rim is completed and notch converted into foramen by transverse lig. Articular branches

of obturator and medial circumflex arteries enter joint through acetabular notch.

Foramen Obturatum.—Below acetabulum. Closed by obturator membrane, which is attached to its margins, except above, at obturator groove, where obturator vessels and nerve pass out of pelvis. On the sides of the groove the *ant.* and *post. obturator tubercles* can be seen sometimes. A ligament stretches between them.

Nutrient foramina of hip bone are scattered.

Ossification.—Primary centre for ilium at 9th week, for ischium during 4th month, for pubis during 5th or 6th month. Rami of pubis and ischium unite at 10th year. Cartilage at bottom of acetabulum is reduced to triradiate strip at 12th year; centres then appear in it and fuse with adjoining bone before 16; one of these secondary centres, between ilium and pubis, is called *os acetabuli*. Five epiphyseal centres appear at puberty and fuse 20-25: (1) Ant. inf. iliac spine; (2) crest and both superior iliac spines; (3) ischial tuberosity; (4) pubic tubercle; (5) pubic angle.

Attachments. Ilium. Inguinal lig. (Poupart's) to **ant. sup. spine**. Sartorius from ant. sup. spine and part of notch below. Tensor fasciæ late from ant. sup. spine, part of notch below and anterior inch of outer lip of crest. Obliquus ext. abdominis to ant. $\frac{1}{2}$ or $\frac{2}{3}$ of **outer lip**; latissimus dorsi from post. $\frac{1}{3}$, fascia lata to whole outer lip. Obliquus internus from ant. $\frac{1}{3}$ of **linea intermedia**. Transversus abdominis from ant. $\frac{2}{3}$ of **internal lip**. Ilio-lumbar lig. and quadratus lumborum to internal lip above posterior part of iliac fossa. Fascia transversalis and iliaca become continuous with one another along inner lip. Long posterior sacro-iliac lig. to **post. sup. spine**. Lig. sacro-tuberosum (great sacro-sciatic) to **post. sup. and post. inf. spines**. Piriformis from upper margin of **greater sciatic notch**. Ilio-femoral lig. to lower part of **ant. inf. spine**; straight head of rectus femoris from upper part; reflected head from roughness on **dorsal surface**, between acetabulum and inf. gluteal line. Gluteus minimus from area between inf. and ant. gluteal lines. Gluteus medius from area bounded by ant. and post. gluteal lines and iliac crest. Gluteus maximus from upper rough part of area behind post. gluteal line. Iliacus from upper part of **iliac fossa**. Sacro-spinalis (erector spinae) from upper part of **iliac tuberosity**; posterior and interosseous sacro-iliac lig. to lower part. Anterior sacro-iliac lig. to convex margin of **auricular surface**.

Ischium and Pubis. Quadratus femoris from lateral margin of **ischial tuberosity**; sacro-tuberos. lig. (great sacro-sciatic) to medial margin; semimembranosus from lateral upper impression; semitendinosus and long head of biceps from medial upper impression; adductor magnus from lowest impression and from margin of

conjoined rami. Gemellus superior, levator ani, coccygeus, sacro-spinous lig. (small sacro-sciatic) from **ischial spine**. Gemellus inferior from lower margin of lesser sciatic notch.

Obturator internus from **pelvic surface** of **ischium** and **ilium**, above and posterior to obturate foramen, from margins of obturate foramen except at obturator groove, and from **obturator membrane**. Levator ani and pubo-prostatic ligaments from pelvic surface of **body of pubis**; adductor longus from femoral surface, in angle between crest and symphysis. Gracilis from margin of **symphysis** and **inf. ramus**; adductor brevis from area lateral to that; obturator externus from area anterior to and below obturate foramen and from medial half of obt. membrane. Fascia lata to crest, margins of symphysis and conjoined rami, and lower end of ischium, medial to gracilis and adductor magnus; and to margin of pubic arch, more medially still, the deep layer of superficial perineal fascia (Colles') is attached.

Crus penis to groove on pelvic surface of rami. Ischio-cavernosus (erector penis), transversus perinei superficialis from or near junction of ischial tuber and ramus, at posterior end of groove for crus. Fasciae of urogenital diaphragm (triangular lig.), sphincter urethrae and transversus profundus, falciform process of lig. sacro-tuberosum (great sacro-sciatic) and lig. arcuatum pubis (sub-pubic) to strip between groove for crus penis and origin of obturator internus.

Fibro-cartilage of symphysis to **symphyseal surface**; anterior, posterior, superior and arcuate (sub-pubic) lig. to its circumference. Aponeurosis of obliquus externus abdominis to **crest** and **symphysis**, and by means of lig. inguinale and lacunare (Poupart and Gimbernat) to **pubic tubercle** and **pectineal line** of same side, and by means of lig. inguinale reflexum (triangular fascia) to opposite pectineal line. Falx inguinalis (conjoint tendon) and fascia transversalis to crest and pectineal line; cremaster to pubic tubercle. Pyramidalis from crest, rectus abdominis from crest and ant. lig. of symphysis. Pectineus from pectineal surface and line, its fascia (pubic portion of fascia lata) to pectineal line. Psoas minor to ilio-pectineal eminence and line.

Transverse lig. bridges across **acetabular notch**. Lig. teres to transverse lig. and margins of notch. Labrum glenoidale (cotyloid lig.) to transverse lig. and **bony rim of acetabulum**. Fibrous capsule to labrum below and anteriorly, to bony rim above and posteriorly and to rough depression above acetabulum. Ilio-femoral lig. to lower part of **ant. inf. iliac spine**. Pubo-capsular lig. to lateral end of **obturator crest**. Ischio-capsular lig. from ischium below acetabulum.

Attached from before backwards to **pubic crest** are fascia lata, obl. ext. abd., falx inguinalis (conjoint tendon), pyramidalis, rectus abd., fascia transversalis; to **pectineal line**, pectineus, its fascia, lig.

lacunare (Gimbernat), lig. reflexum (triangular fascia), falx inguinalis (conjoint tendon), fascia transversalis and psoas minor.

Pelvis.—Hip bones anteriorly and laterally, sacrum and coccyx posteriorly. **Pelvis major** is the part above ilio-pectineal lines and is in relation to abdominal contents. **Pelvis minor**, below, contains pelvic viscera.

Pelvis Minor (True Pelvis or Pelvis).—Bounded anteriorly by symphysis and bodies of pubic bones; laterally by ilium below linea arcuata, ischium, conjoined rami, superior ramus of pubis; posteriorly by sacrum and coccyx. For. obturatum is closed by obturator membrane; interval between hip bone and sacrum is bridged across by lig. sacro-tuberosum and sacro-spinosum (sacro-sciatic lig.).

Apertura Pelvis Minoris Superior (Brim or Inlet).—Bounded by promontory and anterior margin of ala of sacrum, ilio-pectineal line, pubic crest and symphysis. These are grouped under name **linea terminalis**, divided into pars sacralis, iliaca, pubica.

Apertura Pelvis Inferior (Outlet).—Bounded anteriorly by pubic arch, which is formed by lower margin of symphysis and conjoined rami of the two sides; posteriorly by coccyx and, in recent state, by the ligaments; laterally by lower end of ischium.

Cavity of Pelvis.—A short curved canal, $1\frac{1}{2}$ to 2 inches in length anteriorly, 5 or 6 in. posteriorly.

Axis of plane of superior aperture is a line drawn at right angles to its centre, and, if continued, would pass through umbilicus and tip of coccyx. *Axis of plane of inferior aperture* is drawn at right angles to its centre, and, if produced, would strike promontory of sacrum. **Axis pelvis** is a line, curved in conformity with sacrum and coccyx, which passes through centres of planes of sup. and inf. apertures and through centres of a series of planes set between these.

Inclinatio pelvis is such that, in erect posture, anterior superior iliac spine and pubic symphysis lie in same vertical plane, and plane of superior aperture forms an angle of 50° to 60° with the horizontal.

Pelvic Measurements.—Those of apertures of pelvis minor are the most important. **Intercristal diameter**: greatest distance between external lips of iliac crests. **Interspinous diameter**: line between anterior superior iliac spines. **External antero-posterior diameter**: distance from tip of 1st sacral spine to anterior surface of symphysis.

Diameters of Superior Aperture.—(1) *Antero-posterior (conjugate)*, from middle of sacral promontory to upper margin of symphysis. (2) *Transverse*, across aperture where it is widest. (3) *Oblique*, from one sacro-iliac joint to the opposite ilio-pectineal eminence.

Diameters of Cavity.—(1) *Antero-posterior*, from centre of 3rd piece of sacrum to middle of pelvic surface of symphysis. (2) *Transverse*, between pelvic surfaces of ischia, bisecting antero-posterior diameter at right angles. (3) *Oblique*, from lower margin of one sacro-iliac joint to very near centre of opposite obturator membrane.

Diameters of Inferior Aperture.—(1) *Antero-posterior*, from tip of coccyx to lower margin of symphysis. (2) *Transverse*, between medial margins of ischial tubers, bisecting antero-posterior diameter at right angles, but on a lower plane. (3) *Oblique*, from intersection of sacro-tuberous and sacro-spinous ligaments (great and small sacro-sciatic) of one side to junction of rami of ischium and pubis of opposite side.

<i>Measurements given in inches.¹</i>	Female.			Male.		
Intercristal .	11			11½		
Interspinous .	9½			9½		
External antero-posterior	7			7½		
PELVIS MINOR.	Superior Aperture.	Cavity.	Inferior Aperture.	Superior Aperture.	Cavity.	Inferior Aperture.
Antero-posterior	4½	5	4 5 ²	4	4½	3½
Transverse .	5½	5	4¾	5	4¾	3½
Oblique . .	5	5½	4½	4¾	4½	4

¹ The measurements correspond to those given in *Quain*, 10th edition.

² Varies during life from 4 to 5 inches owing to mobility of coccyx.

Sexual Differences.—In female, as compared with male, bones are lighter, more slender, and muscular markings less pronounced. Iliac are less everted, iliac fossæ shallower; anterior superior spines closer together. **Superior pelvic aperture**, reniform rather than heart-shaped, and obliquity of its plane greater; sacral promontory projects less; pubic tubercles wider apart; all diameters are larger. **Cavity** is roomier, less funnel-shaped, shorter, both anterior and posterior walls being of lesser depth; sacrum shorter and wider, and its curve less uniform, being flatter above and more sharply turned forwards below. **Inferior aperture**, larger; pubic arch wider and more rounded; ischia farther apart; sciatic spine less inturned; interval between sacrum and hip-bone (sacro-sciatic notch) wider and shallower; coccyx more movable and projects less forwards. Obturator foramina smaller, may be triangular rather than oval. Acetabula are farther apart and relatively smaller.

Femur. Distal end larger than proximal; shaft is smallest in middle, enlarges towards ends, especially distally.

Proximal end, separated from its fellow by width of pelvis. **Caput (head)**, spherical, directed medially, proximally and forwards; articulates with acetabulum; articular area more extensive on superior and anterior aspects than on posterior and inferior; *fovea capitis femoris* is a pit on postero-inferior quadrant for lig. teres. **Collum (neck)**, nearly $1\frac{1}{2}$ inches long, joins shaft at angle of 125° in adult, but wider in youth. **Upper border** is short and joins trochanter major; **lower border**, long, more sloping, joins shaft at trochanter minor. **Anterior surface** is flat and more nearly on same plane with adjoining parts than posterior; bears smooth impression near head, against which the femoral lig. presses in erect posture; junction with shaft is marked by rough ridge, called *linea intertrochanterica*. **Posterior surface**, rounded, joins shaft on medial side of trochanters, and of *intertrochanteric crest*—the prominent ridge uniting trochanters posteriorly. **Trochanter major**, a large quadrilateral prominence, united to lateral part of neck and proximal end of shaft; overhangs neck; felt subcutaneously at side of hip; tip is opposite centre of hip-joint, on level with upper margin of symphysis pubis; root is defined from shaft by horizontal ridge. Has anterior, posterior, lateral and medial surfaces and a superior border. An oblique ridge for gluteus

medius crosses lateral surface, from postero-superior to antero-inferior angle; *trochanteric fossa* (digital fossa) is a deep depression, for insertion of obturator externus, at posterior and distal part of medial surface; posterior surface is joined to lesser trochanter by inter-trochanteric crest, on which there is a slight eminence called *quadrate tubercle*.

Trochanter minor, small and pyramidal, is situated at distal part of junction of neck and shaft posteriorly.

Distal End. — Lies close to its fellow. Two **condyles** project posteriorly and distally; lie in horizontal plane when shaft is in natural position; articulate with tibia and menisci of knee-joint distally; united anteriorly to form **patellar surface** for articulation with patella; separated posteriorly by **intercondyloid fossa**, which is limited on proximal side by the **linea intercondyloidea**.

Condylus lateralis, broader than medial, shorter antero-posteriorly, projects more anteriorly and extends to more proximal level, long axis less oblique, and distal surface less convex. On posterior part of its lateral surface is a rough eminence, called *lateral epicondyle*. Distal to epicondyle is a pit for origin of popliteus; *popliteal groove* extends proximally from pit, posterior to epicondyle, close to articular margin; tendon of popliteus lies in groove during full flexion of knee, but crosses its distal lip during extension. Impression for origin of lateral head of gastrocnemius is proximal and posterior to epicondyle. **Condylus medialis**, more curved than the lateral, and projects farther distally when femur is vertical. *Medial epicondyle*, the prominence on its medial surface, stands farther away from shaft than the lateral; *adductor tubercle* is eminence at its proximal part. Epicondyles and adductor tubercle are easily felt.

Patellar surface, pulley-shaped, marked off from tibial surfaces of condyles by grooves produced by menisci (semilunar cartilages); can be felt through tendon of quadriceps when knee is flexed; lateral part of pulley is the larger and more prominent.

Corpus Femoris (Body or Shaft). — More or less cylindrical. Expands at both ends, especially distally. In erect posture it slopes distally and medially, because distal ends of femora are in contact, while proximal ends of shafts are separated by pelvis and by the necks of the femora.

Surfaces : *anterior, medial, lateral*, separated by ill-defined *lateral* and *medial borders* and a pronounced *posterior border* called *linea aspera*. Anterior and lateral surfaces give origin to muscles, but medial surface is bare.

Linea aspera is on middle $\frac{1}{3}$ of shaft posteriorly ; its *lateral lip* is thin and sharp, *medial lip* is broader and interrupted. Lips diverge proximally and distally. Proximally, the lateral lip is continued to trochanter major as rough *gluteal tuberosity* for gluteus maximus ; medial lip is continued to linea intertrochanterica as the *spiral line*. District between tuberosity and line makes a posterior surface for proximal part of shaft. Distally, the lips are continued as *lateral* and *medial epicondylar lines*. These extend from linea aspera to respective condyles. Lateral is more prominent than medial, which is worn away, in part, by the passage of the femoral vessels into popliteal fossa. **Planum popliteum** popliteal surface, the space between epicondylar lines, makes a fourth or posterior surface for distal $\frac{1}{3}$ of shaft. It forms floor of popliteal fossa ; roughness on it, proximal to medial condyle, is for medial head of gastrocnemius.

Nutrient Foramina.— One or two near linea aspera, directed proximally.

Ossification.— Primary centre for shaft and neck at 7th week. Epiphyseal centres : for **distal end**, just before birth ; **head**, 1st yr. ; **trochanter major**, 2nd yr. ; **minor**, 12th yr. Fusion takes place in order conforming to size of epiphysis : trochanter minor at 18 ; major, 19 ; head, 20 ; distal end, 21. Epiphyseal line for head is intra-capsular ; for trochanter major and minor, extra-capsular. Line at distal end is partly intra- and partly extra capsular, passes through adductor tubercle and just proximal to patellar surface, and close to intercondylar line.

Attachments. Lig. teres to pit on **head**. Capsular lig. to post. surface of **neck**, $\frac{1}{2}$ inch from inter-trochanteric crest, to upper and lower borders near trochanters, to **inter trochanteric line**. Ilio-femoral lig. and vastus lateralis and medialis to **inter-trochanteric line**. Obturator ext. to **trochanteric fossa** ; tendon of obturator ext. lies directly on the bone beyond attachment of capsule and may produce shallow groove on post. aspect of neck, leading into trochanteric fossa. Obturator internus and gemelli to medial surface of **trochanter major** above neck, piriformis to superior border, gluteus minimus to ant. surface, gluteus medius to oblique ridge on lateral surface, quadratus femoris to *quadrate tubercle* on post. aspect, and line leading distally from it. Vastus lateralis from

lateral and anterior aspects at *root*. Ilio-psoas to **trochanter minor** and to shaft immediately distal to it.

Gluteus maximus to **gluteal tuberosity**, vastus lateralis from its lateral edge. **V. medialis** from **spiral line**. *On surface between tuberosity and line*, from lateral to medial side: upper part of adductor magnus, adductor brevis to distal $\frac{2}{3}$ of strip leading from back of troch. minor to linea aspera (and to proximal part of aspera), pectineus to proximal $\frac{1}{2}$ of same strip, iliacus for 1 inch distal to and anterior to trochanter minor. To **linea aspera** from lateral to medial side: *lateral lip*—vastus lateralis and intermedius (crureus) from proximal and distal parts respectively, lateral intermuscular septum, short head of biceps; *medial lip*—adductor magnus, add. brevis (only to proximal part), add. longus (to distal $\frac{2}{3}$), medial intermuscular septum, vastus medialis (origin).

Lateral epicondylar line: Vastus intermedius, lateral septum, short head of biceps from proximal $\frac{2}{3}$. Plantaris and lateral head of gastrocnemius from distal part, plantaris also from surface proximal to condyle, and gastrocnemius also from adjoining impression on lateral surface of lateral condyle. Adductor magnus and medial septum to **medial epicondylar line**. Vastus medialis from its proximal $\frac{2}{3}$. Medial head of gastrocnemius from rough mark near medial condyle. Vastus intermedius (crureus) from proximal $\frac{2}{3}$ or $\frac{3}{4}$ of *anterior and lateral surfaces of shaft*. Articularis genu (subcrureus) from distal part of ant. surface.

Anterior cruciate lig. of knee to post. part of medial surface of **lateral condyle**; popliteus from *pit* distal to epicondyle; fibular collateral lig. (ext. lateral) to apex of *epicondyle*; lateral head of gastrocnemius from impression behind and proximal to epicondyle. Post. cruciate lig. to ant. part of lateral surface of **medial condyle**; adductor magnus to *adductor tubercle*; tibial collateral lig. to medial epicondyle distal to adductor tubercle. Fascia lata to both condyles. Fibrous stratum of capsule of knee to intercondylar line, to bone just proximal to posterior parts of condyles, to lateral epicondyle proximal to popliteal groove, and to medial condyle, just distal to epicondyle; no definite fibrous stratum anteriorly, but line of reflection of synovial stratum is $\frac{1}{2}$ inch proximal to margin of articular surface.

Muscles with extensive attachments are: **Vastus lateralis** from upper part of inter-trochanteric line, anterior and lateral aspects of root of trochanter major, lateral edge of gluteal tuberosity, proximal part of lateral lip of linea aspera. **Vastus medialis** from lower part of inter-trochanteric line, spiral line, medial lip of l. aspera, proximal $\frac{2}{3}$ of medial epicondylar line. **Vastus intermedius** (crureus) from proximal $\frac{2}{3}$ or $\frac{3}{4}$ of ant. and lateral surfaces of shaft, and distal part of lateral lip of l. aspera. **Adductor magnus** to post. surface of femur, medial to gluteal tuberosity, medial lip of linea

aspera, medial epicondylar line, adductor tubercle. **Short head of biceps** from lateral lip of *linea aspera* and proximal $\frac{2}{3}$ of lateral epicondylar line.

Patella. Sesamoid bone, developed in tendon of quadriceps. Situated in front of distal end of femur. Its distal end is just proximal to level of line of knee-joint.

Vasti and rectus femoris are attached to **base** (proximal border); vastus lateralis and medialis to **lateral** and **medial borders**, respectively; lig. patellæ to **apex** and rough distal part of **posterior surface**. **Anterior surface**, separated from skin by bursa. **Articular surface**, divided by vertical ridge into unequal areas corresponding to large lateral and small medial parts of patellar surface of femur; vertical strip marked off along medial side articulates with condyle, at medial side of intercondylar notch, during full flexion; remainder is divided by the vertical ridge and 2 transverse lines into 3 pairs of facets. **Ossification** begins at 3rd year and is completed at puberty.

Tibia. - Medial and larger bone of leg.

Proximal End. - Larger than distal end; wider transversely than antero-posteriorly; bent slightly backwards. Presents *two condyles*, readily felt at the sides, just distal to knee; continuous with each other anteriorly and smooth for bursa under lig. patellæ, but separated posteriorly by *popliteal notch*. Their proximal surfaces, smooth and articular, are separated by a rough strip, and the contiguous margins are raised up to form *medial* and *lateral intercondylar tubercles*. Each proximal surface articulates centrally with a condyle of femur, peripherally with a meniscus (semilunar cartilage).

Condylus medialis is larger than the lateral, and articular surface is more oval and more concave. On its postero-medial aspect there is a horizontal groove for insertion of semimembranosus. **Condylus lateralis** stands more abruptly away from shaft; presents (1) a nearly circular, flat facet posteriorly, for articulation with head of fibula; (2) smooth shallow groove on post. aspect, medial to facet, for passage of tendon of popliteus; (3) well marked ridge, anterior to facet, for attachment of tractus iliotibialis (ilio-tibial band).

Eminentia intercondyloidea (spine of tibia) is made up of intercondylar tubercles and the rough area between them. *Anterior* and *posterior intercondylar fossæ* are rough depressions, anterior and posterior to eminentia.

Tuberositas tibiæ, the prominence distal to flat surface uniting condyles anteriorly; easily felt; is rough distally, but smooth proximally for attachment of lig. patellæ.

Distal end, quadrilateral. *Medial surface* is prolonged distally as subcutaneous **medial malleolus**, of which the lateral surface articulates with talus (astragalus), distal border is notched and gives attachment to deltoid lig., post. border is grooved by passage of tendon of tibialis posterior. *Lateral surface* is the triangular *incisura fibularis* (*fibular notch*); usually smooth at distal margin for articulation with fibula; rough proximally for ligaments uniting tibia and fibula. *Anterior surface*, rounded; covered by extensor tendons. *Posterior surface*, also rounded; groove on malleolus for tibialis post. encroaches on it; more laterally a faint groove lodges flex. hallucis longus tendon. *Tarsal surface*, quadrilateral, concave antero-posteriorly; articulates with talus.

Corpus tibiæ (Body or **Shaft**) diminishes in size to distal $\frac{1}{2}$ and slightly enlarges again. **Crista anterior**, subcutaneous, extends sinuously from tuberosity to ant. margin of malleolus. **Crista interossea**, from lateral condyle to fibular notch, gives attachment to interosseous membrane. **Margo medialis** extends from medial condyle to post. border of malleolus.

Medial surface, between ant. crest and medial margin, is subcutaneous, except proximally where tendons are inserted. **Lateral surface**, between ant. and interosseous crests, is continuous with anterior surface of distal end. **Posterior surface**, between medial margin and interosseous crest, encroaches on lateral aspect near proximal end; *linea poplitea* crosses it obliquely from fibular facet on lateral condyle to medial margin; *vertical line* passes distally for variable distance, dividing remainder of surface into unequal lateral and medial areas.

Nutrient foramen, near popliteal line, directed distally.

Ossification.—Primary centre at 7th week. Epiphyseal centre for **proximal end**, including proximal part of tuberosity, just before or after birth; fuses at 21; for **distal end** in 2nd year, fuses at 18. Epiphyseal lines are extra-capsular.

Attachments.—Ant. horn of medial meniscus (semilunar cartilage) and ant. cruciate lig. to **ant. intercondyloid fossa**; ant. horn of lateral meniscus to ant. aspect of **intercondyloid eminence**, post. horn to post. aspect; post. horn of medial meniscus to **post. intercondyloid fossa**; post. cruciate lig. to same fossa and to

popliteal notch : all in that order from before backwards. Capsule of knee and fascia lata to **both condyles**. Capsule of tibio-fibular joint around facet on **lateral condyle** : biceps, peroneus longus, ext. dig. longus, tibialis ant., in that order from behind forwards, anterior to facet ; tractus iliotibialis (ilio tibial band) to prominent ridge proximal to these attachments. Semimembranosus to ant. part of horizontal groove on **medial condyle** and into roughness distal to groove. Lig. patelle to smooth proximal part of **tuberosity of tibia**.

Tibialis anterior from lateral condyle and proximal $\frac{2}{3}$ of *lateral surface* of **shaft**. Sartorius, gracilis, semitendinosus, tibial collateral lig. int. lat. of knee to proximal part of *medial surface*, in that order from before backwards, the ligament being attached to roughness near medial margin. Popliteus to **popliteal line** and area proximal to it. Soleus from popliteal line and middle $\frac{1}{3}$ of medial margin. Tibialis posterior from proximal $\frac{2}{3}$ of lateral area of *post. surface* ; fascia covering tibialis posterior to **vertical line** ; flex. dig. longus from proximal $\frac{2}{3}$ of medial area. Fascia of leg to **ant. crest** and **medial margin** ; lig. transversum cruris (upper band of ant. annular to distal part of ant. crest). Interosseous membrane to **interosseous crest**.

Interosseous tibio fibular lig. to floor of **fibular notch** ; ant. and post. lig. of lateral malleolus to its anterior and posterior margins, distally. Ant. lig. of ankle to ant. border of *lateral surface of tibia* ; post. lig. and inferior transverse lig. to post. border. Deltoid lig. (int. lateral of ankle) to distal border of **medial malleolus** ; lig. laciniatum int. annular to its post. border ; lig. cruciatum (lower band of ant. annular) to its ant. border.

Fibula. Lateral and smaller bone of leg. Proximal end cuboidal, distal end slightly compressed from side to side.

Proximal End.—**Capitulum** (head), felt on postero-lateral aspect of leg, on a level with tuberosity of tibia ; common peroneal nerve (ext. popliteal) can be felt and rolled by finger on its posterior surface. *Articular surface*, directed proximally, anteriorly, and medially, articulates with lateral condyle of tibia. *Anterior, posterior, lateral, and medial surfaces*, difficult to recognise till shaft has been examined, give origin to various muscles arising from shaft. *Apex capituli* projects proximally from postero-lateral aspect. **Neck** is the constricted portion distal to head ; common peroneal nerve divides on its lateral aspect.

Distal End Malleolus Lateralis. Distinguished from proximal end by being compressed from side to side, and possessing a pit postero-medially. *Lateral surface* is sub-

cutaneous, and is continued on to shaft as *triangular subcutaneous surface*. *Medial surface* presents a large articular area for talus (astragalus); proximal to that, chiefly on shaft, is a rough triangle for interosseous lig.; distal edge of triangle is sometimes smooth for direct articulation with tibia; posterior and distal to large articular area is a pit for attachment of ligaments. *Posterior surface* is grooved longitudinally by passage of tendons of peroneus longus and brevis—brevis on the bone. *Anterior surface* or *border* is convex, and rough for ligaments.

Corpus Fibulæ (Body or **Shaft**).—Slender, twisted. **Crista anterior**, thin, sharp; recognised by its continuity with apex of triangular subcutaneous surface; extends up to neck. **Crista interossea**, often ill-defined, on medial side of c. anterior, may be very close to it near proximal end; extends from neck to apex of rough triangle on medial surface of distal end; gives attachment to interosseous membrane. **Crista medialis**, often the most prominent of all, medial and posterior to c. interossea, absent in distal part of shaft; begins at neck, joins c. interossea 2 or 3 inches from distal end. **Crista lateralis**, rounded, extends from neck to medial margin of posterior surface of malleolus. **Medial surface**, between anterior and medial crests, is divided by c. interossea into anterior and posterior parts. **Posterior surface**, between medial and lateral crests, is continuous with medial surface of distal end. **Lateral surface**, between lateral and anterior crests, is continuous with posterior surface of distal end.

Nutrient Foramen.—On posterior surface, near middle, directed distally. May be elsewhere and directed proximally.

Ossification.—Primary centre at 7th week. Epiphyseal centre for **distal end** in 2nd year, fuses at 19; for **proximal end**, 3rd or 4th year, fuses after 19. Peculiar in that the epiphysis which begins to ossify first also fuses first. Epiphyseal lines are extra-capsular.

Attachments.—Capsule of tibio-fibular joint around articular surface of **head**. A part of fibrous stratum of capsule of knee, sometimes called "short fibular collateral lig." (short ext. lateral), to tip of *apex capituli*. Fibular collateral lig. (long. ext. lat.), and biceps are attached anterior to apex. Muscles arising from proximal part of shaft arise also from adjoining surfaces of head. Tractus ilio-tibialis (ilio-tibial band) to lateral aspect of head.

From anterior part of *medial surface* of **shaft**: ext. dig. longus from proximal $\frac{2}{3}$, peronæus tertius from distal $\frac{1}{3}$, ext. hall. longus,

medial to these, from middle $\frac{1}{3}$; from posterior part: tibialis posterior. Soleus from proximal $\frac{1}{3}$ of *posterior surface*; flexor hallucis longus from distal $\frac{2}{3}$. Peroneus longus from proximal $\frac{1}{3}$ of *lateral surface*, brevis from distal $\frac{2}{3}$; they overlap in middle $\frac{1}{3}$, brevis being anterior. Ant. intermuscular septum to *anterior crest*, and lig. transversum cruris (upper band of ant. annular) to ant. crest near distal end. Interosseous membrane to *interosseous crest*. Post. intermuscular septum to *lateral crest*.

Ant. lig. of malleolus and ant. talo-fibular lig. (ant. band of ext. lat. lig. of ankle) to ant. border of **lateral malleolus**. Calcaneo-fibular lig. (middle band of ext. lat. lig. to tip. Post. lig. of malleolus to medial edge of post. surface; superior retinaculum of peroneal muscles to medial and lateral edges. Post. talo-fibular lig. (post. band of ext. lat. lig.), and inferior transverse lig. to *fit* posterior and distal to articular surface; interosseous lig. to rough triangle proximal to articular surface.

Tarsus. 7 bones. **Proximal row:** talus, calcaneus. **Intermediate bone:** navicular. **Distal row:** three cuneiforms, cuboid.

Talus (Astragalus). Lies below tibia. Consists of *head*, *neck* and *body*, head being anterior.

Caput. Convex, felt as a prominence 1 in. or more distal and anterior to ankle-joint, when foot is inverted. Articulates anteriorly with navicular, and on its plantar aspect with plantar calcaneo-navicular ligament (spring lig.), and anterior end of dorsal surface of calcaneus. **Collum**, rough for ligaments, slightly constricted. **Corpus:** *Superior surface*, concavo-convex, all articular for distal end of tibia. *Lateral surface* stands away from neck and head, is covered by articular facet for lateral malleolus; everted part below is called *processus lateralis*. *Medial surface*, flush with head and neck, has facet above for medial malleolus, is rough below for deltoid ligament. *Posterior surface*, very small, has oblique groove for lodgment of tendon of flex. hall. longus, and lateral to that a projection called *processus posterior*, which is occasionally separate and called *os trigonum*. *Inferior surface* has large oval, concave facet posteriorly, for calcaneus; a deep groove, anterior to that, for interosseous lig.; and, anterior to that, a facet which encroaches on neck and articulates with sustentaculum tali.

Attachments. Ant. lig. of ankle, and dorsal talo-navicular lig. to upper surface of **neck**, ant. talo-fibular lig. (ant. band of ext. lat. of ankle) to lateral side, deltoid lig. to medial side.

Deltoid lig. also to medial side of **body**. Articular capsule of talo-calcanean joint around large facet on lower surface; interosseous talo-calcanean lig., to groove anterior to that; to posterior margin of lesser facet the membrane closing talo-calcaneo-navicular joint posteriorly is attached. Post. lig. of ankle to upper part of posterior surface. Post. talo-fibular lig. (post. band of ext. lat.) to **processus posterior**.

Calcaneus (Os Calcis).—Lies below talus; forms prominence of heel. Has 6 surfaces. **Dorsal surface**: Saddle-shaped area posteriorly supports fat and areolar tissue in front of tendo calcaneus (Achillis); oval convex facet articulates with talus; groove anterior to that is for interosseous lig., and tunnel formed by it and corresponding groove on talus is called *sinus tarsi*; rough surface anteriorly sometimes has facet medially for head of talus. *Sustentaculum tali* is the horizontal projecting shelf on medial side; may be felt 1 inch below medial malleolus; articulates above with lesser facet on body of talus, is grooved below by passage of tendon of flex. hallucis longus; tendon of flex. digitorum longus is superficial to its edge; medial plantar vessels and nerve are in relation to it, between these two tendons; tendon of tibialis post. lies above it, on deltoid lig. **Plantar surface**: rough, presents *anterior tubercle* at anterior end, and *medial* and *lateral processes* of tuber calcanei at post. end. **Anterior surface** is covered by concavo-convex, sloping facet for articulation with cuboid. **Posterior surface** is the *tuber calcanei*, smooth above for bursa, rough in middle for insertion of tendo calcaneus; lower area, covered by pad of heel, divides below into *medial* and *lateral processes*, of which medial is larger. **Medial surface** is concave, and overhung anteriorly by sustentaculum tali. **Lateral surface**: rough, flat, or slightly convex. Tendons of peroneus longus and brevis pass obliquely downwards and anteriorly over its anterior part, and may produce grooves separated by tubercle, called *processus trochlearis* (peroneal tubercle).

Attachments.—**Dorsal surface**: Capsule of talo-calcanean joint around oval facet; interosseous talo-calcanean lig. to groove; to rough surface anteriorly the ext. dig. brevis, stem of lig. cruciatum (lower band of ant. ann. lig.), stem of lig. bifurcatum (ext. calcaneo-scaphoid and int. calcaneo-cuboid). Deltoid lig. (int. lat. of ankle), plantar calcaneo-navicular lig. (spring) and slip from tibialis posterior to edge of **sustentaculum tali**; to its upper surface, behind its facet, the lig. completing talo-calcaneo-navicular joint is attached. **Plantar**

surface : Lig. laciniatum (int. annular), plantar aponeurosis to, and abductor hallucis, flexor dig. brevis from, medial process of *tuber calcanei*; abductor digiti quinti from both processes; plantar calcaneo-cuboid lig. (short plantar) to *ant. tubercle*; long plantar lig. to rough area posterior to that; lateral head of quadratus plantæ (accessorius) from lateral edge of that area, and medial head from **medial surface**. Dorsal calcaneo-cuboid lig. to lateral and dorsal edges of facet on **anterior surface**. Tendo calcaneus to middle of **posterior surface**. Inferior peroneal retinaculum to margins of grooves and trochlear process on **lateral surface**.

Os Naviculare. On medial side of foot, anterior to talus. **Surfaces** : *Posterior*, concave for head of astragalus. *Anterior* has 3 facets for cuneiform bones. *Dorsal*, flat and rough for dorsal ligaments. *Plantar*, rough, irregular for plantar ligaments, especially plantar calcaneo-navicular. *Lateral*, small, rough for ligaments, but may have facet for cuboid. *Medial* is the prominent **tuberositas**, a landmark felt 1 inch below and anterior to medial malleolus, and is chief point of insertion of tibialis posterior.

Ossa Cuneiformia. Three in number and each is wedge-shaped. They articulate with navicular posteriorly, with first 3 metatarsals anteriorly, by their sides with one another, and the third laterally with cuboid and 4th metatarsal, while first and third grip base of 2nd metatarsal between them. Dorsal, plantar and interosseous tarsal and tarso-metatarsal ligaments are attached to them, and tibialis posterior is inserted into plantar aspects.

Cuneiforme Primum.—The largest. Edge of wedge upwards. **Surfaces** : *Posterior*, small, pyriform, articulates with navicular. *Anterior*, kidney shaped, art. with 1st metatarsal. *Medial*, subcutaneous, convex; impression below and anteriorly for insertion of tibialis anterior. *Lateral*, inverted L shaped facet along upper and posterior borders for 2nd cuneiform and side of 2nd metatarsal base; impression below and anteriorly for insertion of peroneus longus. Base of wedge is *plantar surface*.

Cuneiforme Secundum. Smallest. **Surfaces** : *Anterior*, triangular, articulates with 2nd metatarsal. *Posterior*, triangular, art. with navicular. *Medial*, inverted L-shaped facet along upper and posterior borders for 1st cuneiform. *Lateral*, B-shaped facet along posterior border for 3rd cuneiform. Edge of wedge is *plantar surface* and base is *dorsal surface*.

Cuneiforme Tertium. Distinguished by lateral border of dorsal surface or base being angled, and by large triangular facet for cuboid on postero superior part of *lateral surface*. *Anterior and*

posterior surfaces, triangular, and articulate with 3rd metatarsal and navicular, respectively. B-shaped facet for 2nd cuneiform along posterior border of *medial surface*. Small facets at anterior parts of medial and lateral surfaces for 2nd and 4th metatarsal bases. Edge of wedge is *plantar surface*, and base is *dorsal surface*.

Os Cuboideum.—On lateral side of foot. Dorsal, plantar and interosseous tarsal and tarso-metatarsal lig. attached to rough areas.

Surfaces.—**Dorsal**: flat, rough, in line with lateral surface of calcaneus. **Posterior**: concavo-convex, sloping, articulates with calcaneus. **Anterior**: two facets for 4th and 5th metatarsals. **Lateral**: smallest, shows beginning of groove on plantar surface. **Medial**: large facet and sometimes a small one for 3rd cuneiform; occasional facet posteriorly for navicular. **Plantar**: irregular. Groove for passage of peroneus longus near anterior border; long plantar lig. is attached to its lips. Posterior to the groove is a ridge, lateral end of which is called *tuberositas*, and is faceted by sesamoid bone in peroneus longus tendon. Plantar calcaneo-cuboid lig. and flexor hallucis brevis are attached posterior to ridge, and slip from tibialis posterior to groove.

Metatarsus.—Five bones, numbered 1 to 5 from tibial to fibular side. Each has proximal end or base, a shaft, a distal end or head. **Bases** articulate with tarsus and with one another, and are connected by dorsal, plantar and interosseous tarso-metatarsal and inter-metatarsal ligaments. **Capitulum** of each articulates with first phalanx and plantar accessory lig., which is attached proximal to head, while collateral lig. are attached to the sides of head.

First Metatarsal.—Shortest and stoutest. **Basis**: kidney-shaped facet for 1st cuneiform, concavity of which is directed laterally; occasional facet for 2nd metatarsal; impression on lateral aspect, near sole, for insertion of peroneus longus; tibialis anterior is inserted into medial aspect near sole. **Corpus** (body or shaft): three-sided. *Dorsal surface*, subcutaneous; flexor hallucis brevis lies on *plantar*, 1st dorsal interosseous attached to *lateral*. **Capitulum**: grooved on plantar aspect by sesamoid bones in flex. hall. brevis.

Second, third, fourth metatarsals are compressed from side to side, plantar surface concave. Sides of shaft give origin to dorsal interossei, plantar aspect of 3rd and 4th to first and second plantar interossei. Oblique part of adductor hallucis, tibialis posterior, long plantar lig. are attached to plantar aspect of bases.

Tarsal surface of base slopes laterally and backwards, so that lateral surface of bone, as a whole, is longer than medial, and bone

can be more easily referred to its side than identified. **Second metatarsal**: **Base**, nearly triangular on section, *lateral surface* articulates with 2nd cuneiform; *medial surface* with 1st cuneiform and sometimes with 1st metatarsal; *lateral surface* with 3rd metatarsal and 3rd cuneiform by two double facets, separated by horizontal groove. **Third metatarsal**: **Base**, nearly triangular on section; *lateral surface* articulates with 3rd cuneiform; *medial surface* with 2nd metatarsal by two small facets; *lateral surface* with 4th metatarsal by large facet which occupies upper and posterior angle, and is limited by oblique groove. **Fourth metatarsal**: **Base**, cuboidal; *lateral surface* articulates with cuboid; *medial surface*, with 3rd metatarsal and 3rd cuneiform by large facet; *lateral surface*, with 5th metatarsal by large facet like that on lateral surface of 3rd.

Fifth Metatarsal.—Compressed from above downwards. 4th dorsal and 3rd plantar interosseous arise from plantar surface of shaft, which is slightly concave. **Base** is expanded; peroneus tertius is inserted into *dorsal surface*; flexor digiti quinti arises from *plantar surface*; *lateral surface* articulates with cuboid; *medial*, with 4th metatarsal. *Lateral surface* presents **tuberosity**, a landmark on lateral side of foot, into which peroneus brevis is inserted.

Phalanges.—Great toe has 2, the largest in either foot or hand. Other toes have 3 each, smaller than those of fingers, 2nd and 3rd being often mere nodules. *Shaft* of **first**, compressed from side to side; *base*, relatively large, concave; *head*, pulley-shaped. *Base* of **second** has vertical ridge for groove of pulley of first; *head*, pulley-shaped. *Base* of **third** is like second but more expanded; *head*, expanded, rough on plantar surface.

Attachments—Ligaments—plantar accessory lig. of metatarsophalangeal and inter-phalangeal joints to *anterior part* of bases and heads, and collateral ligaments to their sides, and three flexor sheaths to sides of shaft of 1st of great toe, 1st and 2nd of other toes.

Tendons—**First phalanx of great toe**: flexor hallucis brevis to both sides of *base*, abductor to medial side, adductor to lateral side, first tendon of ext. dig. brevis to dorsum. **First of little toe**: abductor to lateral side of *base*, fourth lumbrical and third plantar interosseous to medial side. **First of other toes**: plantar and dorsal interossei and lumbricals to sides of *base*. **Second of great toe**: flex. hallucis longus to plantar surface of *base*, ext. hall. longus to dorsum. **Second of other toes**: flex. dig. longus to sides of *base*, median slip of extensor expansion into dorsum of *base*. **Third of other toes**: flex. dig. longus into plantar surface of *base*, collateral slips of extensor expansion into dorsum.

Ossification.—**Tarsus**: centre for **calcaneus**, 6th month, **talus**, 8th month, **cuboid**, at birth. **Third cuneiform**, 1st year, **second cuneiform**, 2nd or 3rd year, **first cuneiform** and **navicular**, 3rd or 4th year. Epiphyseal centre for *tuber calcanei*, 7th to 9th year. Ossification completed, 16 to 20. *Posterior process of talus* may have separate centre, and may remain separate as **os trigonum**.

Metatarsus.—Centre for *shaft and base* of **second**, **third**, **fourth**, **fifth**, early in 3rd fetal month. Epiphyseal centre for *head*, 2nd to 4th year; fuses at 18. Centre for *shaft and head* of **first** in 3rd month. Epiphyseal centre for *base*, 2nd or 3rd year, fuses at 18. Epiphyseal lines are extra-capsular.

Phalanges.—Centre for *shaft and head* of **third** at end of 3rd month, of **first** at end of 4th month, of **second** of second and third toes during 6th month, of fourth toe at birth, fifth toe after birth. Epiphyseal centres for *bases* about 4th year; fuse from 16 to 18, those of first phalanges before others. Epiphyseal lines are extra-capsular.

Ossa Sesamoidea.—Two small nodules in tendon of flexor hallucis brevis and one in peronæus longus. Sesamoid bones of hand and foot may be mistaken for pisiform, but sesamoid is thinner and articular facet covers whole of one surface, is not flat but irregular and more elongated proximo-distally. Sesamoids of hand are usually very small.

SYNDESMOLOGY (ARTICULATIONS)

BONES may be united in five different ways and the joints formed between them are classified, according to the mode of union, as : (1) Synostosis, (2) Suture, (3) Syndesmosis, (4) Sychondrosis, (5) Diarthrosis.

Synostosis.—*Immovable.* The coalescence of two bones originally united by (a) fibrous tissue, e.g. two halves of mandible, and two halves of frontal bone ; or by (b) cartilage, e.g. basilar part of occipital and body of sphenoid.

Suture.—*Practically immovable.* Found in the skull. Articulating edges or surfaces of bones are connected by intervening **sutural membrane**, which is continuous by its edges with periosteum on both surfaces of the bones. Ossification occurs in this membrane till sutures have disappeared and the bones have coalesced—synostosis. Some coalesce early, e.g. halves of frontal bone ; some persist till advanced age.

Varieties. *S. serrata*, between bones with serrated or denticulated edges, e.g. inter-parietal. *S. squamosa*, between bones with overlapping edges—parietal and squamous temporal. *Harmonia*, between plane surfaces, e.g. inter-maxillary. Union between root of a tooth and its socket is allied to suture and is termed *gomphosis*.

Syndesmosis. Union by intervening **interosseous ligament**, permitting slight yielding movement, e.g. distal ends of tibia and fibula.

Sychondrosis.—Two varieties : 1. Bones united by intervening plate of **hyaline cartilage**, perichondrium of which is continuous with periosteum on each side. They are formed between : (1) basi-occiput and body of sphenoid ; (2) ethmoid and body of sphenoid ; (3) petrous temporal and

jugular process of occipital ; (4) bodies of vertebræ and vertebral arches ; (5) all diaphyses and epiphyses. They are immovable. They disappear by ossification, some during childhood, the remainder during adolescence.

11. Union by **fibro-cartilage**. Articulating surfaces are coated with articular cartilage and united by a fibro-cartilaginous disc, which is surrounded by fibrous membrane, and may have a small cavity or cleft in the centre, lined with synovial membrane. These synchondroses allow partial or yielding movement. They are found only *in median plane*—between bodies of vertebræ ; between segments of sternum ; and between pubic bones. They persist between bodies of **movable** vertebræ and between pubic bones. This variety of synchondrosis is often called amphiarthrosis, and often called **symphysis**, e.g. symphysis pubis ; but the term symphysis is applied also to the osseous union (synostosis) between the halves of the mandible—symphysis menti.

Diarthrosis.—*Movable joint*. Includes most joints of the body. Articular surfaces are coated with **articular cartilage**, and are surrounded by an **articular capsule** enclosing an **articular cavity**, which contains an oily fluid called *synovia*. Articular capsule consists of a *fibrous stratum* or *capsular ligament*, lined with a *synovial stratum* or *membrane*. The fibrous stratum or **capsular ligament** is the essential bond of union between the bones. It is attached beyond the margins of the articulating surfaces and is frequently strengthened by thickenings of its substance, by expansions from deep fascia, or by accessory ligaments. **Synovial stratum** secretes synovia, lines fibrous stratum, and is reflected on to bone and onwards to overlap edges of articular cartilage ; it also covers structures found within fibrous stratum of some joints, and excludes them from articular cavity. These are—(A) Fibro-cartilaginous structures connected with fibrous stratum and separating articulating surfaces : (a) **articular discs**—found in mandibular, sterno-clavicular, and acromio-clavicular joints, and between distal end of ulna and carpus ; (β) **articular menisci** (semilunar cartilages) of knee. (B) **Labrum glenoidale**, the fibro-cartilaginous ring encircling glenoid cavity of scapula (glenoid ligament), and the acetabulum (cotyloid ligament). (C) Ligaments stretching across joint, binding articulating structures more firmly : (a) **inter-articular ligaments** of heads of 2nd to 9th ribs, and of 2nd and sometimes the succeeding costo-sternal joints ; (β) **lig. teres** of hip-joint ;

(γ) **cruciate ligaments of knee.** (δ) Tendons arising within fibrous stratum of joints: (α) long tendon of *biceps* in shoulder-joint; (β) tendon of *popliteus* in knee.

Diarthrodial joints are permanent, except some of the chondro-sternal joints, in which the cavity may be obliterated by growth of the interarticular ligament. (The diarthrosis between 1st cartilage and sternum has been lost and first costo-sternal joint resembles the first variety of synchondrosis, but the cartilage does not disappear.)

Varieties of diarthrodial joints. *Arthrodia*: simple gliding movement, as between carpal bones. *Ginglymus* or *hinge joint*, and *trochoides* or pivot joint: movement around one axis, as in elbow, and movement of atlas and skull around dens (odontoid process). *Ellipsoidea* or condyloid joint: movement around two axes, as in wrist joint. *Sellaris* or saddle joint: saddle-shaped surfaces reciprocally adapted to each other, as in 1st carpo metacarpal joint: movement around two axes. *Enarthrosis* or ball-and-socket joint: multi-axial, movement in every direction, as in shoulder and hip joints.

JOINTS AND LIGAMENTS OF VERTEBRAL COLUMN

Between Vertebral Bodies. Synchondrodial joints: (1) **Intervertebral fibro-cartilages** (intervertebral discs) are attached firmly to upper and lower surfaces. Fibrous circumferentially; pulpy and exceedingly elastic in centre. Contribute largely to cervical and lumbar curvatures; form $\frac{1}{4}$ of length of vertebral column. (2) **Ligamentum longitudinale anterius** and (3) **Lig. longitudinale posterius** are attached to fibro-cartilages and margins of bodies. They lie on anterior and posterior surfaces of bodies, respectively, and extend from atlas to sacrum. (4) *Articular capsules* surround small diarthrodial joints between lateral parts of bodies in cervical region.

Between Vertebral Arches.—(1) **Articular capsules** connect articular processes and surround diarthrodial joints between them. (2) **Ligamenta flava** are elastic and are attached to inner surface and lower border of lamina above in cervical and lumbar regions, to inner surface only in thoracic region; to outer surface and upper border of lamina below. Seen, therefore, from within vertebral canal.

Connected with capsule laterally ; medial edge of each is thickened and separated from its fellow by small interval filled with fatty areolar tissue. (3) **Ligamenta interspinalia** are attached to contiguous spines, from base to tip. (4) **Ligamentum supraspinale** is attached to tips of spines, along whole length of column. Strongest in neck, where it forms *ligamentum nuchæ*, a triangular sheet between muscles of the two sides of back of neck, attached by its base to external occipital crest, by apex to 7th cervical spine, by anterior margin to the other cervical spines ; posterior margin gives attachment to trapezius, rhomboideus minor and splenius. (5) **Ligamenta intertransversaria**, very weak, connect transverse processes.

Between 5th Lumbar Vertebra and Sacrum.—Same joints and ligaments as between two typical vertebrae, with, in addition, the **lumbo-sacral ligament**, a triangular band, covered by psoas major, attached by apex to 5th lumbar transverse process, by base to ala of sacrum, blending with anterior sacro-iliac ligament.

Between Sacrum and Coccyx.—*Fibro-cartilage* and *anterior* and *posterior sacro-coccygeal ligaments* connect 5th sacral and 1st coccygeal bodies ; *interarticular ligaments* connect corresponding cornua ; *lateral sacro-coccygeal ligaments* connect lower lateral angles of sacrum with transverse processes of 1st piece of coccyx.

Movements of Vertebral Column.—Limited between any 2 vertebrae ; considerable over column as a whole. **Flexion** is most extensive of all ; least in thoracic region. *Produced* mainly by sterno-mastoid, longus colli, longus capitis (rect. cap. ant. major), scaleni, rectus abdominis, psoas major and minor. *Checked* by posterior part of fibro-cartilage and all ligaments dorsal to that. **Extension** is limited ; least in thoracic region. *Produced* mainly by 4th layer of muscles of back. *Checked* by ant. longitudinal ligament, fibro-cartilages, and approximation of spines. **Lateral flexion** is best marked in cervical region, where it is always combined with rotation. *Produced* by 4th and 5th layers of back muscles and by splenius, scaleni, quadratus lumborum, psoas major. *Checked* by all ligaments on opposite side, by resistance of ribs and sternum. **Circumduction** is a combination of above movements. **Rotation** is best marked in upper thoracic, absent in lumbar region. *Produced* by sterno-mastoid, scaleni, longus capitis, semispinales, multifidus, rotatores, abdominal muscles. *Checked* by locking of articular processes, resistance of twisted fibro-cartilages and all the ligaments.

Joints between 1st and 2nd Cervical Vertebrae.—**Articular capsules** surround diarthrodial joints between dens (odontoid process) and anterior arch of atlas, and between lateral masses of atlas and superior articular surfaces of 2nd cervical.

Each of the latter is strengthened postero-medially by a strong *accessory lig.* which extends from post. surface of body of 2nd cervical, upwards and laterally, to postero-medial aspect of lateral mass of atlas; these joints are homologous with small diarthroses between sides of bodies of other cervical vertebrae. A continuation of **lig. longitudinale ant.** unites body of 2nd to anterior arch of atlas, and is seen between longi capitis. The first **ligamentum flavum** unites laminae of 2nd to posterior arch of atlas, and is covered by obliquus inferior. **Ligamentum transversum atlantis**, attached to medial surface of each lateral mass, holds dens (odontoid process) in position against ant. arch, and is separated from it by synovial bursa. It is ruptured in drop hanging. **Ligamentum cruciatum** consists of the transverse ligament, with a band stretching from its upper border to basi-occiput within foramen magnum, and another from its lower border to dorsum of body of 2nd cervical vertebra.

ARTICULATION OF VERTEBRAL COLUMN WITH CRANIUM

Between Atlas and Occipital Bone. — Articular capsules connect lateral masses with occipital condyles and surround the diarthroses between them. These correspond to small diarthrodial joints between sides of bodies of cervical vertebrae. **Membrana atlanto occipitalis anterior** connects anterior arch to anterior half of circumference of foramen magnum; continuous with capsules laterally; covered by rectus capitis anterior (minor); related to lig. alaria and lig. apicis dentis posteriorly. A thickening in median plane is upper end of **ant. longitudinal lig.** **Membrana atlanto occipitalis posterior** connects post. margin of for. magnum to post. arch of atlas between grooves for vertebral arteries; joins capsules laterally; covered by rectus capitis posterior minor and obliquus superior; adherent to dura mater anteriorly. Above vertebral grooves it presents a free border, thickened and sometimes ossified, converting groove into foramen for vertebral artery and sub-occipital nerve.

Between 2nd Cervical Vertebra and Occipital Bone. — (1) **Lig. cruciatum.** (2) **Ligamentum apicis dentis** (suspensory ligament) extends from apex of dens (odontoid process) to anterior margin of foramen magnum, and lies between ant. atlanto-occipital membrane and upper band of cruciate ligament; it contains remains of notochord. (3) **Ligamenta alaria**, from sides of apex of dens to medial sides of occipital condyles. (4) **Membrana tectoria**, broad and flat, is continuous with post. longitudinal ligament; attached to dorsum of body of 2nd vertebra and to grooved upper surface of basi-occipital; it covers cruciate ligament, dens and its ligaments.

Lig. nuchae also connects vertebra to cranium.

Movements.—I. *Between 2nd cervical and atlas together with head.* **Rotation** around dens, *produced* mainly by semispinalis capitis (complexus) and sterno-mastoid of one side. with obliqui, rectus posterior major, splenius, longissimus, and longus capitis (rectus. cap. ant. major) of opposite side; *checked* by lig. alaria.

II. *Between atlas and cranium.* **Flexion**, *produced* mainly by longus capitis and rectus anterior; *checked* by posterior ligaments. **Extension**, mainly by recti posteriores, semispinalis capitis, splenius, trapezius, sterno-mastoid (which flexes cervical vertebræ); *checked* by anterior ligaments. **Lateral movements** very slight, *produced* by rectus lateralis, sterno-mastoid, trapezius (splenius, semispinalis capitis); *checked* by capsules and lig. alaria.

ARTICULATIO MANDIBULARIS

Mandibular joint (temporo-maxillary) is diarthrodial. Condyle of mandible articulates with mandibular fossa and articular tubercle (eminentia articularis) of temporal bone, articular disc intervening. **Capsula articularis** surrounds articular surfaces. *Lig. temporo-mandibulare*, thickened lateral part of capsule, attached to zygoma and tubercle at its root and to lateral surface and posterior border of neck of mandible; covered by skin, fascia, parotid. **Discus articularis** divides joint cavity into two; attached circumferentially to capsule, and anteriorly to pterygoideus externus also; conforms to articular surfaces—lower surface concave, upper surface concavo-convex. *Ligamentum speno-mandibulare* (internal lateral) on medial side of joint, but not in contact, extends from spine of sphenoid to lingula and margins of mandibular foramen. Derived from membrane around Meckel's cartilage. Lower end lies upon pterygoideus int. It is separated from mandible, from above downwards, by auriculo-temporal nerve, pterygoideus externus; int. maxillary vessels, inferior alveolar (dental) vessels and nerve.

Vessels and Nerves.—Superficial temporal and masseteric arteries; auriculo-temporal and masseteric nerves.

Movements.—**Depression**, produced by digastric, mylo-hyoid, genio-hyoid, platysma, and by gravity. **Elevation**, by masseter, pterygoideus internus, temporalis. These movements take place around an axis passing through mandibular foramina. **Protrusion**, by pterygoidei, anterior part of temporalis, superficial fibres of masseter. **Retraction**, by posterior part of temporalis, deep part of masseter. **Grinding**, by pterygoidei of

opposite sides acting alternately. In protrusion and retraction movement is mainly between disc and temporal bone. When depression and elevation are slight it is mainly between disc and condyle, when considerable it is in both situations, and disc and condyle both pass forwards on to articular tubercle. Depression is checked by temporo-mandibular ligament. Sudden excessive depression may lead to dislocation.

Relations.—**Superficial** or **lateral** to mandibular joint are skin, fasciæ and parotid gland, and some of the temporal branches of facial nerve emerging from parotid. A little below are the transverse facial vessels and zygomatic branches of facial nerve.

Pterygoideus externus is inserted into **anterior aspect** of joint and the nerve and vessels to masseter pass laterally, above the pterygoideus externus, anterior to the joint.

Posterior aspect is related to parotid gland, which separates it from both cartilaginous and osseous parts of external acoustic meatus; but when jaws are closed the condyle of mandible exerts pressure on the cartilaginous part, through the parotid. The pressure is relieved when mouth is opened; this may be tested by placing the finger in the meatus. Superficial temporal artery and upper part of posterior facial vein, which accompanies the artery here, lie between joint and parotid, near the skin surface. Auriculo-temporal nerve, at first medial to the joint, runs laterally, posterior to the joint, between it and parotid, before as ending over post. root of zygoma.

Medial to the joint are the spine of sphenoid and sphenomandibular lig., a little distance away. Auriculo-temporal nerve passes posteriorly and laterally between the ligament and the capsule of the joint. Internal maxillary artery, with its vein, is passing anteriorly and medially between the ligament and neck of mandible, below the joint. Chorda tympani is medial to spine of sphenoid. Middle meningeal artery, ascending to for. spinosum, antero-medial to sphenomandibular lig., is less than $\frac{1}{2}$ inch from joint. Internal carotid artery is in line with anterior margin of acoustic meatus, about $\frac{1}{2}$ inch medial and a little posterior to the joint, and separated from the joint by the most medial part of tympanic plate; when it enters carotid canal it is separated from joint cavity by osseous part of auditory tube. Mandibular nerve is $\frac{1}{2}$ inch or more from medial side of joint, in line with, and about $1\frac{1}{2}$ inches directly medial to, tubercle at root of zygoma.

Above the joint is the middle cranial fossa; and the trunks of middle meningeal vessels groove the floor of the fossa directly above the tuberculum articulare (eminentia articularis).

CRANIAL LIGAMENTS NOT DIRECTLY ASSOCIATED WITH JOINTS

Ligamentum stylomandibulare, a portion of sheath of parotid gland derived from cervical fascia, extends from styloid process to posterior border and angle of mandible; separates parotid and submaxillary glands. **Lig. stylohyoideum**, from tip of styloid to lesser horn of hyoid bone; lies between hyo-glossus and genio-glossus; may contain fleshy fibres, may ossify, and corresponds to epihyal found in many animals; derived from membrane around cartilage of 2nd arch. **Lig. pterygo-spinosum**, from lateral pterygoid plate to spine of sphenoid. May ossify and form, with base of skull, a foramen transmitting nerves to pterygoideus externus, temporalis and masseter.

ARTICULATIONES COSTOVERTEBRALES

Costo-vertebral joints are diarthrodial.

Articulationes Capitulorum.—Head of typical rib with vertebra of corresponding number and vertebra above and fibro-cartilage between them. **Articular capsule**, attached to margins of articulating surfaces. *Lig. radiatum*, the thickened anterior part of capsule, radiates in three bands from anterior surface of head of rib to fibro-cartilage and bodies of the two vertebræ; pleura and sympathetic trunk are related to its anterior surface. **Inter-articular ligament** extends from crest of head of rib to fibro-cartilage, and is attached to capsule in front and behind. It divides joint cavity into upper and lower parts; absent in 1st, 10th, 11th, 12th joints, where rib articulates with only one vertebra.

Articulationes Costo-transversariæ.—Tubercle of rib with transverse process of vertebra of corresponding number. Absent in 11th and 12th ribs. **Articular capsule** surrounds joint. Its greatly thickened postero-lateral part, attached to rough part of tubercle and to transverse process near tip, is called *lig. tuberculi costæ* (post. costo-transverse).

Accessory Ligaments.—(1) *Anterior costo-transverse lig.*, from crest of neck of rib, upwards and laterally, to transverse process above; absent from 1st rib; continuous laterally with post. intercostal membrane. Medial free border bounds aperture for transmission dorsally of posterior branches of intercostal vessels; posterior surface related to longissimus dorsi; anterior, to intercostal vessels and nerve. *Lig. lumbocostale*, in the same series, extends from 1st lumbar transverse process to neck of 12th rib and 12th

thoracic transverse process. (2) *Posterior costo-transverse lig.* extends from postero-superior aspect of neck to junction of lamina and transverse process above. (3) *Lig. colli costæ*, from posterior surface of neck of rib to anterior surface of transverse process. It is rudimentary in 11th and 12th ribs.

ARTICULATIONS BETWEEN RIBS AND COSTAL CARTILAGES.—Cartilage is received into a pit at end of rib and held there by continuity of periosteum and perichondrium.

INTERCHONDRAL ARTICULATIONS.—Diarthrodial. 5th to 9th and sometimes 10th costal cartilages articulate by oblong, elevated facets on contiguous margins. These are surrounded by articular capsules strengthened on deep and superficial surfaces.

ARTICULATIONES STERNOCOSTALES

First costal cartilage is directly implanted on sternum, and perichondrium and periosteum are continuous. **Second to seventh** articulate by **diarthrodial joints** opposite lines of union of segments of sternum, except in case of sixth, which articulates with 4th segment of body of sternum.

Articular capsule surrounds each joint. **Ligamenta sternocostalia radiata**, thickened anterior and posterior parts of capsules, unite with those of opposite side, and in front form *membrana terni*. **Lig. interarticulare** stretches from cartilage to sternum, inside joint, and divides its cavity into two; it is always present in 2nd; inconstant in others; sometimes obliterates cavity of 6th and 7th. **Ligamenta costoxiphoidea** connect back and front of xiphoid process with 7th and sometimes 6th cartilage.

ARTICULATIONS OF PARTS OF STERNUM

Body of sternum articulates with manubrium by synchondrosis, and is united to xiphoid process by fibrous tissue as in a suture.

Movements of Ribs

Around two axes. (1) Whole rib is moved around axis passing through sternum and posterior end of shaft of rib. (2) Anterior end of rib, with sternum, is raised and thrust forwards by movement around axis passing obliquely through capitular joint along neck of rib, in front of costo-transverse joint. **Elevation**, in ordinary inspiration, is produced by intercostals and subcostals; **depression**, by elasticity and gravity.

Movements in Respiration. — Ordinary respiration may be *abdominal* or *thoracic* in type, or a combination of these two. In the *abdominal* type, **inspiration** is produced by the diaphragm. The central tendon and the peripheral attachments are relatively fixed. The fleshy fibres contract and straighten, and therefore descend between the points of their attachment, changing the dome of the diaphragm into a cone with the apex cut off, and enlarging the thoracic cavity; while abdominal viscera are displaced, and push anterior abdominal wall before them. **Expiration** is brought about by the elastic recoil of the abdominal wall, which, acting through the viscera, pushes the diaphragm up again into its position of rest. Ordinary quiet abdominal respiration is accompanied by exceedingly little movement of thoracic walls.

In *thoracic* type, ordinary quiet **inspiration** is produced by intercostals, but is accompanied by movement of diaphragm, unless there is some impediment to its action. In ordinary inspiration the 1st and 2nd ribs move little, if at all. The middle parts of the shafts of 3rd to 6th ribs are raised like pail handles and, therefore, increase the transverse diameter of thorax; for ribs are arcs of circles increasing in size from above downwards, and each is raised towards the position of the one above. The anterior ends also are raised; and, since ribs are oblique in position, that means that they are thrust ventrally as well, raising and pushing forwards the body of the sternum, which moves at the sternal synchondrosis. The antero-posterior diameter is increased in this way, and the transverse as well, for the costal ends of costal cartilages are raised with the ribs, so that the oblique costal cartilages come to occupy positions nearer the horizontal, and push the anterior ends of the ribs further away from median plane.

Anterior ends of 7th to 10th ribs also are slightly elevated. The shafts are not only raised, but are drawn laterally and dorsally. That movement undoes the movement of the anterior ends in the ventral direction, but increases the infra-costal angle and the width of the thorax, and increases also the capacity of upper part of abdomen, in order to accommodate abdominal viscera, displaced by descent of diaphragm.

Expiration is brought about by gravity and the elasticity of the ligaments and costal cartilages.

Twelfth rib is fixed by sacrospinalis, quadratus lumborum, and fascia, and its fixation renders 11th rib practically immovable.

In *forced respiration* the head and shoulders are fixed; the sternomastoid and trapezius, and all muscles attached to ribs and costal cartilages may be called into play. All the movements are exaggerated, and, in addition, the manubrium and anterior ends of 1st and 2nd ribs are raised, and the vertebral column is straightened and bent dorsally during inspiration. At the end of forced inspiration the anterior abdominal wall is retracted, for it follows the viscera

as they retreat into the space created at upper part of abdominal cavity by the increased springing out of 7th to 10th ribs.

ARTICULATIONS OF SUPERIOR EXTREMITY

Articulatio Sternoclavicularis. Diarthrodial. Sternal end of clavicle with clavicular notch of sternum, articular disc intervening and with first costal cartilage. **Articular capsule** surrounds joint; is thickened anteriorly to form *lig. sternoclaviculare*, which extends from anterior surface of clavicle to ant. surface of manubrium, and is covered by sternal head of sterno-mastoid. Sterno-hyoid and sterno-thyroid are in relation to posterior part of capsule, and, behind them, the innominate artery on right side, common carotid artery on left. **Discus articularis** divides joint cavity; attached to ant. and post. parts of capsule, to upper part of sternal end of clavicle above, to first cartilage near sternum below. **Accessory ligaments.** *Costo-clavicular lig.* extends from first cartilage upwards, laterally and posteriorly to costal tuberosity of clavicle; origin of subclavius is anterior to it, innominate vein is posterior. *Interclavicular lig.*: subcutaneous. Attached to rough upper part of sternal ends of both clavicles and to upper margin of manubrium. Blends with upper parts of the capsules. Related to sterno thyroids posteriorly.

Movements.—(1) Clavicle moving on articular disc: **elevation of shoulder**, *produced* by upper part of trapezius, levator scapulae, sterno-mastoid, rhomboids; *checked* by costo-clavicular ligament. **Depression**, by subclavius, pectoralis minor, lower part of trapezius, and by gravity; *checked* by disc and interclavicular ligament. (2) Clavicle and disc moving on sternum: **movement forwards of shoulder**, by serratus anterior, pectoralis minor; **backwards**, by trapezius and rhomboids. (3) **Circumduction** is a combination of these. Dislocation is prevented mainly by disc and interclavicular ligament.

Articulatio Acromio-clavicularis.—Diarthrodial. Acromial end of clavicle with facet on medial margin of acromion, articular disc intervening. **Articular capsule** attached to margins of articular surfaces: subcutaneous above and strengthened to form *acromio-clavicular lig.*: in relation to supraspinatus below. **Discus articularis**: usually incomplete, often absent. Attached to capsule above, projects

down into joint cavity. **Accessory ligament** = coraco-clavicular lig. Its chief function is to suspend major part of upper limb from clavicle. It also prevents dislocation, which tends to be upwards, owing to oblique direction of articular surfaces at this joint. It is in relation to deltoid and subclavius anteriorly, to trapezius posteriorly. It consists of two parts : (1) *Trapezoid lig.* situated antero-laterally, broad and flat; attached to upper surface of coracoid process and to trapezoid ridge of clavicle; lateral border is free. (2) *Conoid lig.* placed postero-medially; base is attached to coracoid tuberosity of clavicle, apex to coracoid process near scapular notch; medial border free, lateral border joined to trapezoid, and a bursa occupies angular recess between them in front.

Movements.—Scapula follows clavicle in its movements, but by slight gliding at this joint it is able, while following clavicle, to remain applied to chest wall and retain direction of glenoid cavity practically unchanged in its relation to head of humerus.

Ligaments of Scapula.—**Lig. coraco-acromiale** forms, with coracoid process and acromion, an arch for greater protection and security of shoulder-joint. Flat and triangular in shape. *Apex* attached to tip of acromion, anterior to facet for clavicle; *base* to lateral border of coracoid process. Thinnest in centre, where it is sometimes perforated by prolongation of tendon of pectoralis minor to capsule of shoulder-joint. *Upper surface* is in relation to deltoid and clavicle, *lower* to supraspinatus, subacromial bursa intervening. **Lig. transversum scapulæ superius** (supra-scapular), attached to superior margin of scapula and to base of coracoid process. Bridges across scapular notch; may ossify. Omo-hyoid arises from it. Transverse scapular (supra-scapular) vessels cross above it, supra-scapular nerve below it. **Lig. transversum scapulæ inferius** (spino-glenoid). Very slender. May be absent. Stretches from lateral border of spine to back of head of scapula. Transverse scapular vessels and supra-scapular nerve pass deep to it on their way to infra-spinous fossa.

Articulatio Humeri (Shoulder-joint).—Diarthrodial. Enarthrodial (ball and socket). Head of humerus with glenoid cavity of scapula.

Labrum glenoidale (glenoid ligament) is a ring of dense fibro-cartilaginous tissue, triangular on section, attached by the base to margin of glenoid cavity, which it deepens. Long tendon of biceps is largely incorporated in it superiorly.

Capsula Articularis.—Exceedingly lax. *Fibrous stratum* capsular lig. is attached proximally to margin of glenoid cavity, beyond the labrum, and to labrum itself; distally to anatomical neck of humerus close to articular head above, to surgical neck, nearly half an inch from head, below. Synovial stratum protrudes through three openings in the fibrous stratum to form *bursæ*; one opening is under subscapularis at base of coracoid, another is between tubercles, and through it the long tendon of biceps emerges; a third, rarely present, is under infraspinatus. Tendons of subscapularis, supra- and intra-spinatus fuse with capsule near their insertions and strengthen it, and by pulling it away during their contraction prevent nipping of the lax capsule. Capsule is least supported by muscles below, and dislocation most often takes place there.

Accessory Ligaments of Capsule. *Lig. coracohumerale*, on upper aspect of capsule, represents prolongation of pectoralis minor tendon; extends from lateral margin of base of coracoid process to anatomical neck at greater tubercle. Blends with capsule behind and distally; anterior border is free. *Glenohumeral ligaments, superior, middle and inferior*, are ill-defined bands extending from margin of glenoid cavity to anatomical neck, between synovial and fibrous strata of capsule. *Transverse humeral ligament*, a thickened prolongation of capsule, bridges across groove between tubercles, and holds long tendon of biceps in position.

Synovial stratum lines fibrous stratum of capsule and is prolonged on to labrum glenoidale, and on to neck of humerus up to articular margin. It gives a synovial sheath to long tendon of biceps within the joint, and for some distance after emergence from the joint. It protrude through the apertures to form bursa under subscapularis and intra-spinatus.

Nerve and Blood Supply.—Supra-scapular and axillary (circumflex) nerves; transverse scapular—supra-scapular and humeral circumflex vessels.

Relations. (1) *Immediate.* Subscapularis and its bursa *anteriorly*; supraspinatus *superiorly*; infraspinatus and bursa *inferiorly*; teres minor *posteriorly*—all in close contact. Long head of triceps, posterior circumflex vessels and axillary (circumflex) nerve, in quadrilateral space, are in close contact *inferiorly*, when arm is abducted. Long tendon of biceps passes *through the joint*

over head of humerus, but is excluded from cavity by its synovial sheath.

(2) **More remote.** Coraco-acromial arch overhangs it *above*, and large subacromial bursa is underneath arch and deltoid. *Anteriorly*, short head of biceps, coraco-brachialis, axillary vessels and the nerves in axilla are separated by subscapularis. *Inferiorly*, teres major is separated by post. circumflex vessels and axillary nerve in quadrilateral space. Deltoid overlaps anteriorly, posteriorly, laterally and above, but is nowhere in contact with capsule, being separated by coracoid process, coraco-acromial lig., bursa, and muscles attached to tubercles (tuberosities).

Movements. — **Flexion** (movement forwards), *produced* by pectoralis major, coraco-brachialis, anterior part of deltoid, biceps. **Extension** (movement backwards), by latissimus dorsi, teres major and minor, post. part of deltoid, infraspinatus, long head of triceps.

Abduction, by deltoid and supraspinatus; ceases when arm is at a right angle to body, further elevation being produced by shoulder girdle moving at sterno-clavicular joint. **Adduction**, by subscapularis, pectoralis major, teres major and minor, latissimus dorsi, coraco-brachialis, long head of triceps, and by gravity. **Circumduction**, a combination of these four movements.

Medial rotation, much stronger than lateral rotation owing to the number of muscles employed, viz., pectoralis major, anterior part of deltoid, subscapularis, latissimus dorsi, teres major. **Lateral rotation**, by infraspinatus, teres minor, posterior part of deltoid.

Articulatio Cubiti (Elbow-joint). — Includes humero-ulnar, humero-radial and proximal radio-ulnar joints. The former two are considered together and form a diarthrodial, hinge joint. Trochlea and capitulum of humerus with semilunar notch of ulna and head of radius, respectively.

Fibrous stratum of **articular capsule** is subdivided into four parts: (1) *Anterior ligament*, broad and thin, attached proximally to proximal margins of radial and coronoid fossae and to medial epicondyle; distally to margin of coronoid process and to annular (orbicular) ligament. (2) *Posterior ligament*, very thin. Attached proximally to margins of olecranon fossa on each side, and across its floor proximally, and to lateral epicondyle; distally to anterior and lateral margins of olecranon. (3) *Lig. collaterale radiale* (ext. lateral) extends from distal aspect of lateral epicondyle to annular ligament. (4) *Lig. collaterale ulnare* radiates from distal aspect of medial epicondyle to medial margins of coronoid process and olecranon, and to a transverse band which bridges across interval between them.

Synovial stratum lines fibrous stratum, covers bone within capsule up to margins of articular surfaces, and lines proximal radio-ulnar joint. Pads of fat lie between fibrous and synovial strata in relation to radial, coronoid and olecranon fossæ.

Blood-Vessels.—The anastomosis around elbow-joint. **Nerves:** ulnar, musculo-cutaneous, median, radial (musculo-spiral).

Relations.—**Anterior:** brachialis covers nearly whole of ant. lig.; and some of its fibres arise from it. It separates brachial artery and venæ comites, tendon of biceps, and median nerve from the joint. Medial to brachialis the volar (anterior) recurrent ulnar artery is in relation to ant. lig., overlapped by pronator teres. Lateral to brachialis the ant. ligament is covered by brachio-radialis and ext. carpi rad. longus, and under cover of these lie radial recurrent art., deep and superficial branches of radial nerve, radial and post. interosseous branches of musculo-spiral. **Lateral:** common tendon of extensors overlies radial collateral lig., while ext. carpi radialis brevis and supinator arise from it. **Medial:** common tendon of flexors overlies ant. band of ulnar collateral lig., and flexor sublimis arises from it; flexor carpi ulnaris overlies post. band, and ulnar nerve and post. ulnar recurrent art. lie directly on it. **Posterior:** triceps and bursa cover proximal and medial part and some fibres of triceps are inserted into it. Anconæus and interosseous recurrent artery lie upon distal and lateral part.

Movements.—**Flexion:** *produced* mainly by biceps, brachialis, pronator teres, brachio-radialis, assisted to a small extent by flexors and extensors of hand and fingers, which are attached to ant. aspects of epicondyles; *checked* by contact of forearm and arm.

Extension: mainly by triceps and anconæus, *checked* by anterior and collateral ligaments before olecranon, and touch humerus. Axis of movement and line of articulation are oblique; hence extended forearm forms with the arm an obtuse angle laterally; and in flexion hand is carried towards mouth.

Articulatio Radio-ulnaris Proximalis. Diarthrodial, pivot joint. Circumference of head of radius encircled by annular ligament and radial notch of ulna.

Ligamentum annulare radii (orbicular lig.) forms $\frac{3}{4}$ or $\frac{1}{2}$ of circle. Attached to ant. and post. margins of radial notch of ulna. Distal margin is very loosely connected to neck of radius, if at all; proximal margin gives attachment to anterior and radial collateral ligs. of elbow. Supinator arises from outer surface; prolongation of synovial stratum of elbow lines inner surface, and is reflected on to neck of

radius, and over it to margin of head. Diameter is less across distal than proximal margin; hence radius is securely held in position. In interval between radius and ulna the *lig. quadratum* connects ant. and post. parts of distal margin of lig. annulare and is attached to neck of radius and distal margin of radial notch of ulna.

Articulatio Radio-ulnaris Distalis.—Diarthrodial, pivot joint. Head of ulna with ulnar notch of radius laterally, and articular disc distally. **Articular capsule**: very thin proximally; *fibrous stratum* consists of *anterior* and *posterior radio-ulnar lig.* passing between margins of articular surfaces in front and behind. **Discus articularis** (triangular fibro-cartilage) completes joint distally. Attached by base to edge separating carpal and medial surfaces of distal end of radius, by apex to pit between styloid process and head of ulna, by its margins to dorsal and volar radio-carpal ligaments. Both surfaces are covered with synovial stratum; proximal surface articulates with head of ulna, distal with os lunatum and triquetrum (semilunar and cuneiform).

Synovial stratum, very loose, covers articular disc, lines ant. and post. ligaments, bulges proximally between radius and ulna as *recessus sacciformis*.

Accessory Ligaments connecting Radius and Ulna.—**Chorda obliqua**, a slender band extending from tuberosity of ulna distally and laterally to radius, distal to its tuberosity. **Membrana interossea**: broad, thin, strong. Attached to interosseous crests of radius and ulna and to the posterior of the two ridges into which that of radius divides distally. Extends from one inch distal to radial tuberosity to capsule of distal radio-ulnar joint, with which it blends.

Interosseous membrane binds radius and ulna together, and increases surface for origin of muscles. Its fibres run mostly from radius, distally and medially, to ulna, permitting shocks, transmitted to radius from hand, to be passed on to ulna and thence to humerus. Flexor pollicis longus and digitorum profundus arise from proximal $\frac{2}{3}$ of **volar surface**, and volar interosseous vessels lie between them, and perforate it near distal end; pronator quadratus lies on distal fourth. **Dorsal surface** gives origin to abductor pollicis longus, extensor poll. brevis and longus, and extensor indicis proprius, while supinator lies on it proximally, volar interosseous vessels and dorsal interosseous nerve distally. **Hiatus interosseus** is the gap between it and chorda obliqua, for passage backwards of dorsal interosseous vessels.

Movements of Radio-ulnar Joints.—Initiated by brachio-

radialis. **Pronation**, *produced* mainly by pronator teres and quadratus, and brachio-radialis. **Supination**, mainly by supinator, biceps, brachio-radialis.

Position of supination is that in which the bones of forearm are parallel, and thumb is directed laterally.

Position of pronation is that in which radius is crossed in front of ulna, the proximal end remaining lateral, and thumb is directed medially. Arm is held usually in intermediate position, in which the interval between the bones is widest, or in the prone position; but in the description of structures in the forearm it is assumed that the limb is in supine position and dependent.

Movement of supination brings forearm and hand from intermediate or prone position into supine position. **Movement of pronation** reverses. Supination is the stronger movement, owing to strength of biceps; and screws and crutches at the joints are constructed accordingly. **Axis of movement** passes through centre of head of radius and apex of articular disc. Head of radius rotates within annular ligament. Distal end of radius is pivoted with it, and revolves around head (distal end) of ulna; ulna, therefore, moves with radius, and its ulnar attachment is the centre of movement.

Starting from supine position, the forearm and hand can be rotated so that palm, originally looking forward, looks successively medially, backwards and laterally, and moves through 270°. Greater part of that movement is not pronation, but medial rotation at shoulder-joint, assisted by some movement at elbow-joint. Pronation alone can move hand through about 130° at the elbow, but proximal to ulnar margin of dorsum of wrist, where only the styloid process of ulna and tendon of extensor carpi ulnaris. The thumb lies proximal to ulnar side of dorsum of wrist in prone position, on the lateral surface and a small part of anterior surface of head of ulna, while styloid process and tendon may be felt proximal to dorsal aspect of wrist.

Articulatio Radiocarpea (Wrist-joint). Diarthrodial, condyloid. Distal surface of radius and triangular articular disc form an elliptical concavity for convex surface formed by ossa naviculare, lunatum (semilunar) and triquetrum (cuneiform), and their interosseous ligaments.

Articular capsule surrounds joint, and is strengthened by the following bands. (1) *Dorsal radiocarpal lig.*, extends distally and medially from dorsal margin of distal end of radius to dorsal surfaces of naviculare, lunatum and triquetrum. (2) *Volar radiocarpal lig.*, from volar margin of distal end of radius and its styloid process and from head of ulna, to proximal row of carpal bones and to capitatum (magnum). (3) *Lig. collateralare laterale* (int. later.). A round cord

passing from styloid process of ulna to triquetrum (cuneiform) and pisiforme. (4) *Lig. collaterale radiale* (ext. lateral), from radial styloid process to tuberosity of naviculare (scaphoid) and to multangulum majus (trapezium).

Blood-Vessels.—Carpal branches of radial and ulnar, interosseous, recurrent branches of deep volar arch. **Nerves:** dorsal and volar interosseous, dorsal branch of ulnar.

Movements are supplemented by movements at intercarpal joints. **Flexion**, produced by flexor carpi radialis and ulnaris, palmaris longus (and flexors of digits). **Extension**, by ext. carpi radialis longus and brevis, and ext. carpi ulnaris (and ext. of digits). Extension is freer than flexion; this is more than counterbalanced by greater freedom of "flexion" at intercarpal and carpo-metacarpal joints.

Abduction or radial flexion by extensores radiales, extensors of thumb and flexor carpi radialis. **Adduction or ulnar flexion** by flexor and extensor carpi ulnaris. More extensive than abduction. **Circumduction** is a consecutive combination of these four.

Movement is checked in each case by ligaments; restrained in some positions by tendons, e.g. when fingers are flexed the stretched extensor tendons do not allow full flexion of wrist. Abduction is less free than adduction owing to styloid of radius meeting carpus.

Relations. **Immediate:** *Anterior:* superficial volar art., flex. pollicis longus, flex. digitorum profundus, with their sheaths, from radial to ulnar side; and recurrent branch from deep volar arch and terminal branches of volar interosseous nerve are deep to profundus. *Lateral:* radial artery. *Posterior:* extensores pollicis longus, digitorum communis, and indicis proprius, digiti quinti, carpi ulnaris, with their sheaths, from radial to ulnar side; termination of volar interosseous vess. and dorsal interosseous n. are deep to tendons. *Medial:* dorsal branch of ulnar n. and dorsal ulnar carpal art.

More remote: *Anterior:* flexor carpi radialis, palmar branch of median n., palmaris longus, median nerve, flexor sublimis, ulnar artery, palmar cutaneous branch of ulnar nerve, ulnar nerve, flex. carpi ulnaris. Transverse carpal lig. (ant. annular) is just distal to level of joint, volar carpal arterial arch is just proximal. *Lateral:* abductor longus and extensor brevis pollicis and their sheaths, separated from radial collateral lig. by radial artery. *Posterior:* dorsal carpal lig. (post annular) crosses obliquely. Dorsal carpal arterial arch is distal to joint.

Relations examined in more Detail.—With forearm prone: Locate head (i.e. distal end) and styloid process of ulna, styloid process and dorsal tubercle of radius, and ascertain the line of the joint on dorsal aspect. Beneath the skin are veins and branches of cutaneous nerves.

At radial side, proximal to metacarpal of thumb, feel the tendons of abductor pollicis longus and ext. pollic. brevis. They form the antero-lateral boundary of hollow on radial side of wrist. Under cover of them the radial art. is lying on radial collateral lig. In the hollow at radial side of wrist superficial branches of radial nerve cross the joint; they may be felt more distally, as they cross ext. pollic. longus tendon. Radial art. may be felt pulsating in the distal part of the hollow, on multangulum majus (trapezium), beyond wrist-joint, near carpo-metacarpal joint of thumb.

Next, at ulnar side of the hollow, feel the tendons of ext. carpi rad. longus and brevis, and the ext. pollic. longus. Ext. pollic. longus crosses ext. carpi rad. longus and brevis obliquely, lying on brevis opposite the joint. Next, in order, come ext. dig. communis, with ext. indic. proprius deep to its radial edge; ext. dig. quint., and ext. carpi ulnaris, felt at ulnar border of this aspect. All these tendons are enclosed in synovial sheaths. Dorsal carpal lig. (post. annular) lies obliquely across joint, superficial to tendons its distal border being proximal to joint on radial side, and distal to it on ulnar side. Branches from interosseous art. pass deep to tendons to anastomose with dorsal carpal arch, which lies on a transverse line of carpus; and termination of dorsal interosseous nerve crosses joint under cover of ext. indicis proprius.

With forearm supine. Feel ridge on distal extremity of radius, and ascertain line of joint on palmar aspect of right thumb, proximal level than on dorsal aspect. Some superficial veins lie beneath the skin.

The tendons seen extending distally across middle of this aspect are flex. carpi radialis laterally, and palmaris longus medially; palmaris may be absent.

Feel tubercle of navicular (scaphoid) just proximal to ball of thumb, in angle between it and the first radial, and the scaphoid, which forms knob just proximal to ball of little finger. Proximal border of transverse carpal lig. (ant. annular) stretches between them, and a little distal to wrist joint, usually crosses most distal of art. vessels in crease.

Feel the radial artery beating on distal end of radius, before it turns laterally to reach radial side of wrist, it sends superficial volar branch across the joint to ball of thumb.

Flexor pollicis longus tendon crosses the joint directly dorsal to flex. carpi radialis, which lies under its synovial sheath. Flexor profundus, on ulnar side of pollicis, is in relation to greater part of ant. lig. of joint, and is enveloped in sheath common to it and sublimis. Median nerve is, at this level, anterior to tendon of pronator flexor opposite interval between it and pollicis, on radial side of sublimis. The nerve is posterior to ulnar edge of flexor carpi rad. lig., and posterior to palmaris longus, if the two tendons are close together. Palmar cutaneous branch of median nerve is ascending superficially between flex. carpi rad. and palmaris.

Superficial to pronator flex., on ulnar side of median nerve, are the 4

tendons of flexor sublimis, those for middle and ring fingers being anterior to the other two. Palmaris overlaps them on radial side, but on ulnar side of palmaris the tendon to ring finger can be seen or felt moving while fingers are being flexed.

Ulnar artery and nerve are lying on profundus, close to flex. carpi ulnaris, between it and flex. sublimis, the nerve on ulnar side of artery, which may be felt beating if hand is dorsi-flexed. Palmar cutaneous branch of ulnar nerve passes towards palm upon ulnar artery. Flexor carpi ulnaris is felt at ulnar border of this aspect, proximal to pisiform. It is separated from joint by an interval containing areolar tissue and fat, and by ulnar nerve and flex. profundus, which it overlaps.

Recurrent branch from deep volar (palmar) arch runs proximally across the joint, deep to profundus, to anastomose with volar (ant.) carpal arch, which lies on radius proximal to joint; and terminal branches of volar interosseous nerve are descending to supply volar ligaments of wrist and intercarpal joints.

Between flex. carpi ulnaris and ext. carpi uln. the dorsal branch of ulnar nerve and dorsal carpal branch of ulnar artery run distally upon ulnar aspect of wrist-joint, beneath the skin.

Articulatio Intercarpea (Intercarpal Joints).—Diarthrodial, arthrodial. Bones of proximal row are united by dorsal, volar and interosseous ligaments; bones of distal row united by the same. Proximal row is united to distal row by dorsal, volar and collateral ligaments. Pisiforme is united to triquetrum by articular capsule, to hamatum (unciform) and 5th metacarpal by ligamentum piso-hamatum and piso-metacarpeum, respectively.

Articulationes Carpo-metacarpeæ.—Diarthrodial, mostly arthrodial. Medial four metacarpals are united to carpus by dorsal, volar and interosseous ligaments. First metacarpal is united to multangulum majus (trapezium) by **articular capsule**.

Articulationes Intermetacarpeæ.—Diarthrodial, arthrodial. Bases of medial four metacarpals are united by dorsal, volar and interosseous ligaments.

Joints between pisiforme and triquetrum (cuneiform) and between multangulum majus and 1st metacarpal have each a separate cavity. The other intercarpal, carpo-metacarpal, and inter-metacarpal joints have a common cavity and synovial stratum. Joint between hamatum and 4th and 5th metacarpals is separate occasionally.

Movements of intercarpal, carpo-metacarpal, and inter-metacarpal joints. Slight gliding movements for the most part. At joint between proximal row and distal row of carpus some flexion, extension and rotation are possible; and at carpo-metacarpal joints of thumb and little finger movement is considerable.

At carpo-metacarpal joint of thumb the movements are: **Flexion**, *i.e.* movement of metacarpal forwards in

front of plane of palm, *produced* by flexor pollicis longus and brevis and opponens. **Extension**, by extensors of thumb and abductor pollicis longus. **Adduction**, *i.e.* approximation to index finger, by adductor pollicis. **Abduction**, by abductors longus and brevis. **Opposition** is a combination of (1) flexion, (2) medial rotation produced by opponens, and (3) adduction, whereby the metacarpal and ball of thumb are carried forwards and medially to overhang hollow of palm, and the slightly flexed thumb can touch the tips of the slightly flexed fingers, in succession. **Circumduction** is a combination of all the movements.

At carpo-metacarpal joint of little finger movement is freer than in those of other fingers. Metacarpal can be opposed by the flexor brevis and opponens drawing it forwards and rotating it laterally towards hollow of palm.

Opposition of both thumb and little finger, supplementing flexion of thumb and fingers, enables the hand to grasp a spherical object securely.

Articulationes Metacarpo-phalangeæ. — Diarthrodial, condyloid. Head of metacarpal with base of 1st phalanx. **Articular capsule** is defective dorsally, where expanded extensor tendon replaces fibrous stratum, but is strengthened at sides and on volar (palmar) aspect by collateral and volar accessory ligs. : *Collateral ligaments* are attached to sides of head of metacarpal and to base of phalanx; *lig. accessorium volare*, dense and fibro cartilaginous, is attached loosely to metacarpal, near head, firmly to base of phalanx. Forms part of socket for head of metacarpal. Its volar surface is covered by flexor tendons and their mucous sheaths. Three **ligamenta capitulorum transversa** (**transverse metacarpal**) lie between heads of medial 4 metacarpals and connect the margins of the 4 volar accessory ligaments; lumbricals and digital vessels and nerves lie on their volar surfaces, interosseous muscles on dorsal surfaces.

Movements. — **Flexion** by flexors, interossei and lumbricals. **Extension and dorsi flexion** by extensors. **Abduction and adduction**, from and to middle line of middle finger, by interossei. A combination of these four is **circumduction**. Adduction and abduction of thumb occurs at carpo-metacarpal, not at metacarpo-phalangeal joint. Fingers cannot be abducted when they are flexed owing to tension of dorsal part of capsule and of collateral ligs., and cannot remain abducted during process of flexion owing to the line of pull of flexor tendons.

Articulationes Digitorum (Interphalangeal Joints).—Diarthrodial, hinge-joints. Capsule and collateral and volar accessory ligaments, as in metacarpo-phalangeal joints.

Movements.—**Flexion**, by flexors; **extension**, by extensors, interossei and lumbricals. Full flexion of both wrist and fingers cannot occur at same time, nor can full extension; because opposing muscles do not stretch sufficiently to allow it.

Position of metacarpo-phalangeal and interphalangeal joints on dorsal aspect is on distal side of knuckles. On volar aspect the position of metacarpal joint is about $\frac{1}{2}$ inch proximal to free edge of web; of 1st interphalangeal, opposite proximal crease; of 2nd, on distal side of crease.

ARTICULATIONS AND LIGAMENTS OF PELVIS

LIGAMENTS UNITING VERTEBRAL COLUMN TO HIP BONE

I. **Ilio-lumbar lig.**, the thickened lower part of anterior lamella of lumbo-dorsal fascia, extends from 5th lumbar transverse process to inner lip of iliac crest, above posterior part of iliac fossa. Sacro-spinalis is dorsal to it. Quadratus lumborum arises from its upper surface. Psoas major lies on its ventral surface.

II. **Lig. sacro-tuberosum** (Great Sacro-sciatic) stretches across gap between sacrum and hip bone; forms postero-lateral boundary of inferior aperture of pelvis and of perinaeum, and postero-medial boundaries of greater and lesser sciatic foramina. Broad at both ends, narrow in middle. Attached *superiorly* to posterior iliac spines, 3rd, 4th, 5th transverse tubercles of sacrum and to side of coccyx, *inferiorly* to medial margin of ischial tuberosity, and to ramus of ischium by a prolongation of its medial part called **processus falciformis**, to free margin of which the lower edge of obturator fascia is attached.

III. **Lig. sacro-spinosum** (Small Sacro-sciatic).—Triangular. **Apex** is attached to ischial spine, **base** to side of coccyx and of lower part of sacrum. It lies between the sciatic foramina, and completes their boundaries.

Relations of Sacro-tuberous Lig.—*Dorsal surface* covered by gluteus maximus, which arises from it; long tendon of biceps, of which it represents the proximal end cut off by outgrowth of ischium, is partly continuous with it. Secondary plexus formed by post.

branches of upper 3 sacral nerves lie on it, under cover of gluteus maximus. *Pelvic surface* is in relation to piriformis, sacro-spinous ligament and obturator internus.

Coccygeal branch of inferior gluteal artery threads its way through it; 5th sacral and coccygeal nerves and branches of coccygeal plexus pierce it.

Relations of Sacro-spinous Lig.—*Dorsal surface* is blended with sacro-tuberous ligament medially, and is crossed laterally by pudendal nerve. Internal pudendal vessels lie on its apical attachment. *Pelvic surface* is blended with coccygeus, of which it is a degenerated part. 5th sacral and coccygeal nerves and branches of coccygeal plexus pierce the ligament.

Foramen Ischiadicum Majus (Greater Sciatic).—**Bounded** by greater sciatic notch and the sacro-spinous and sacro-tuberous ligaments (small and great sacro-sciatic). **Transmits:** piriformis; superior gluteal vessels and nerve *above piriformis*; and *below piriformis*, inferior gluteal and internal pudendal vessels; sciatic, posterior cutaneous (small sciatic), inferior gluteal and pudendal nerves, and nerves to quadratus femoris and obturator internus.

Foramen Ischiadicum Minus (Lesser or Small Sciatic).
Bounded by lesser sciatic notch and the two ligaments. **Transmits:** tendon of obturator internus, pudendal int. pudico nerve, internal pudendal vessels.

IV. Articulatio Sacro-iliaca.—Diarthrodial. Auricular surfaces of sacrum and ilium. **Articular capsule** is strengthened by: (1) Thin *anterior sacro-iliac ligament*, attached to anterior and to interior or pelvic margins of auricular surfaces. (2) *Interosseous sacro-iliac lig.* Very thick and exceedingly strong, as it suspends sacrum and superimposed trunk between hip bones. Attached to rough areas above and posterior to auricular surfaces of sacrum and ilium. (3) *Short posterior sacro-iliac lig.* Attachment is posterior to interosseous lig., and includes 1st and 2nd transverse tubercles of sacrum. It is covered by sacrospinalis. (4) *Long posterior sacro-iliac lig.* extends from posterior superior iliac spine (which is at level of centre of joint) to 3rd transverse tubercle of sacrum. It is blended with lower part of short ligament, and is covered by gluteus maximus.

Fibrous bands are often found within joint cavity uniting auricular surfaces.

Relations. **Posterior surface** is covered by sacrospinalis (erector spine). **Abdominal or antero-superior surface** is

covered by psoas major and iliacus ; is crossed, under cover of psoas, by ilio-lumbar vessels ; obturator nerve is separated from the joint by ilio-lumbar vessels ; femoral (ant. crural) nerve is separated by fibres of iliacus. Common and ext. iliac veins are separated from joint by a fatty areolar tissue containing obturator n. and ilio-lumbar vessels ; and common iliac and trunk of hypogastric (int. iliac) arteries are further separated by these veins.

Pelvic surface is closely related to hypogastric (int. iliac) vein, lumbo-sacral trunk, superior gluteal vessels, 1st sacral nerve, upper part of piriformis, in that order from above downwards. They cross the joint obliquely, downwards and laterally. Ant. division of hypogastric art. (int. iliac) is separated from joint by hypogastric vein, and post. division by lumbo-sacral trunk ; but relations of vessels vary.

Symphysis Pubis.—Fibro-cartilaginous synchondrosis. Symphyseal surfaces of pubic bones are covered with encrusting cartilage, and united by fibro-cartilaginous lamina, which is often cleft in the centre, and is covered by weak *superior* and *posterior*, strong *anterior* and *inferior* ligaments. Ligaments are attached to margins of symphyseal surfaces and to the fibro-cartilage. Inferior or *arcuate ligament* (sub-pubic) rounds off pubic arch. Its attachments extend on to inferior rami of pubis. It is very thick in median plane, and has a free, crescentic lower margin.

Relations.—Bladder and urethra, with prostate in male, are related to **pelvic surface**, but are separated from it by pad of fat, veins and fascia in space of Retzius. Neck of bladder in male, in erect posture, is a little below the level of upper margin of symphysis, and $2\frac{1}{2}$ inches posterior to it ; in female it is on level of a line uniting lower margin of symphysis to lower end of sacrum. *Inferiorly* and *posteriorly* are the dorsal vein of penis, close to arcuate lig., and urethra, 1 inch away.

Movements and Mechanism of Pelvic Joints.—Sacro-iliac joint, though diarthrodial, is practically immovable. There is a slight yielding at symphysis pubis. During later period of pregnancy ligaments become relaxed, so that sacrum can be driven backwards, and interval between pubic bones widened, to provide more room during parturition.

The tendency of the weight of the trunk to drive sacrum downwards is obviated by strength of interosseous and posterior sacro-iliac ligaments, and by the interlocking of irregularities of auricular surfaces. Weight of trunk falling on anterior part of sacrum tends to tilt base of sacrum downwards, and apex upwards. This is prevented by the sacro-tuberos, sacro-spinous (sacro-sciatic) and posterior

ARTICULATIONS OF INFERIOR EXTREMITY 111

sacro-iliac ligaments. Tendency for sides of bony ring of pelvis to give way under the strain is provided against by support received from femora. Lumbo-sacral articulation is very oblique, and tendency for last lumbar vertebra to slip into pelvis under the weight of the body is checked by the strength of intervertebral fibro cartilage and ilio-lumbar ligament, and by locking of articular processes. Presence of sacro iliac joints diminishes shocks transmitted to vertebral column, through pelvis, from lower limbs.

ARTICULATIONS OF INFERIOR EXTREMITY

Articulatio Coxæ (Hip-joint).—Diarthrodial: enarthrodial (ball and socket). Head of femur with acetabulum. **Ligamentum transversum acetabuli** completes rim of acetabulum by bridging across acetabular notch, which it converts into foramen for passage of vessels and nerves to joint. **Labrum glenoidale** (cotyloid ligament) is a fibro-cartilaginous ring, triangular on section, attached by base to rim of acetabulum and transverse ligament: it deepens acetabulum; its surfaces are inclined so that it narrows the rim of acetabulum, and grasps head of femur.

Capsula Articularis.—*Fibrous stratum* is very strong; least strong postero-interiorly. Attached *proximally* to bony rim of acetabulum above and behind, to labrum and transverse ligament in front and below: *distally* to inter-trochanteric line anteriorly, to root of neck of femur above and below, to posterior surface of neck, $\frac{1}{2}$ inch from inter-trochanteric crest. Longitudinal fibres are most numerous anteriorly; circular fibres are most numerous posteriorly and below, and form a band or collar called *zona orbicularis*. *Retinacula* are some deep fibres reflected proximally on to neck from distal attachment, and become attached to margin of head; better marked before epiphysis fuses.

Accessory bands of capsule: (1) *Lig. ilio-femorale*, on anterior aspect of capsule. Strongest ligament in the body. Triangular in shape. Attached by apex to lower part of anterior inferior iliac spine, by base to inter-trochanteric line. (2) *Lig. pubo-capulare*, a few fibres extending from superior pubic ramus to lower part of capsule. (3) *Lig. ischio-capulare*, a sheet of fibres extending from ischium below acetabulum to posterior and lower part of capsule, where it blends with zona orbicularis.

Ligamentum Teres Femoris. Not round, but flattened and triangular. Lies within joint, surrounded by tube of synovial membrane. Attached by apex to fovea on head of femur, by bifid base to transverse ligament and margins of acetabular notch. Function doubtful. May be absent.

Synovial stratum lines fibrous stratum, covers both surfaces of labrum glenoidale, is prolonged over fat (Haversian gland) lying in acetabular fossa, and over lig. teres, enclosing it in tubular sheath. It is reflected from distal attachment of capsule up to articular margin of head of femur, enclosing neck in a tube, which the retinacula raise into folds. Sometimes it communicates with bursa under psoas major, through an aperture between ilio-femoral and pubo-capsular bands.

Blood Supply.—Branches of sup. and inf. gluteal, medial and lateral circumflex, and obturator. **Nerves** from femoral (ant. crural), obturator, and nerve to quadratus femoris.

Relations.—(1) **Immediate**: *Posterior*: Piriformis above, and lying more on superior aspect near insertion. Obturator internus and gemelli below; upper edge of quadratus femoris overlaps it medially, but is below level of joint laterally; nerve and vessels to quadratus femoris descend vertically between obt. int. and gemelli and the bone, and then between quadratus and capsule. Glutæus minimus lies on *superior aspect*. *Anterior*: Lateral edge of pectineus overlaps capsule medially. More laterally is psoas major tendon, with iliacus gaining partial insertion to its lateral edge; psoas is separated from capsule by bursa, but some fibres of iliacus are attached to capsule. Lateral to iliacus is rectus femoris; its straight head covers proximal attachment of ilio-femoral lig., its reflected head is imbedded in capsule above acetabulum, under cover of glutæus minimus. Distal lateral part of ilio-femoral lig., in angle between rectus femoris and glutæus minimus, is concealed by tensor fasciæ latæ, but is separated from it by fatty areolar tissue containing ascending branches of lateral circumflex vessels, and through this tissue the deep lamina of tractus iliotibialis (iliotibial band) reaches capsule to fuse with it. *Inferior*: Obturator ext. lies against inferior aspect and turns upwards to insertion, in relation partly to capsule and partly to posterior aspect of neck of femur, beyond attachment of capsule. Medial circumflex vessels, as they pass posteriorly between psoas and pectineus, are below joint, and their deep (ascending) branches accompany tendon of obt. externus. Insertion of psoas and iliacus is below distal part of capsule.

(2) **More Remote**: *Superior*: Glutæus medius covers minimus, and between them are branches of superior gluteal vessels and

nerve. *Posterior*: Sciatic, posterior cutaneous (small sciatic), inferior gluteal nerves and inf. gluteal (sciatic) vessels are separated from joint by obturator internus and gemelli, but the nerve to obt. internus, and pudendal (quadr.) vessels and nerve, in relation to ischial spine, are $1\frac{1}{2}$ inches medial to the joint. Obturator maximus covers all these, and covers quadratus femoris as well. *Anterior*: Upper part of tensor fasciæ latæ is separated by rectus and anterior part of gluteus minimus. Sartorius is separated from joint by rectus femoris, which it crosses, and by iliacus, which it overlaps. Femoral nerve (ant. crural), lying between iliacus and psoas, is separated by fibres of iliacus; femoral art. and lumbo-inguinal nerve (crural or genito-crural) are separated by psoas; femoral vein is separated by contiguous margins of psoas and pectineus. *Interior*: Obturator nerve, emerging from pelvis, is about $\frac{1}{2}$ inch medial to lower aspect.

Movements.— Every possible movement, but less extensive in range than in shoulder joint, as articular cavity is much deeper and ligaments are stronger and not so lax.

Flexion. *produced* by ilio-psoas, rectus femoris, sartorius, pectineus, obturator externus, adductor longus and brevis, and medial part of adductor magnus, anterior parts of gluteus medius and minimus; *checked* by contact of thigh and abdomen when knee is bent, by tension of hamstrings when knee is extended.

Extension. *produced* by gluteus maximus, hamstrings, ischial part of adductor magnus, and by gravity; *checked* by ilio-femoral ligament. Extension is complete when thigh is a straight line with trunk. In erect posture a line dropped from centre of gravity falls behind line joining centres of hip-joints. Trunk leans, therefore, to roll backwards, and is prevented by tension of ilio-femoral lig.

Abduction. *produced* by gluteus medius, minimus, upper part of maximus, tensor fasciæ latæ, sartorius, and obturator externus, and, when limb is flexed, by piriformis and obturator internus; *checked* by pubo capsular and medial part of ilio-femoral ligament.

Adduction. *produced* by the adductors, pectineus, gracilis, quadratus femoris, lower part of gluteus maximus; *checked* by contact with other limb, but, if thigh is flexed, by lateral part of ilio-femoral ligament.

Circumduction is a combination of above movements.

Lateral rotation. much stronger than medial rotation, *produced* by gluteus maximus, posterior parts of medius and minimus, both obturator and gemelli, piriformis, quadratus femoris, sartorius, pectineus, adductors longus, brevis, magnus, and, when thigh is flexed, by psoas; *checked* by ilio-femoral lig., especially lateral part.

Medial rotation. by anterior parts of gluteus minimus and medius, tensor fasciæ latæ, and, during process of flexion, by ilio-psoas; *checked* by ischio capsular lig. and tension of opposing muscles.

Articulatio Genu (Knee-joint).— Diarthrodial : chiefly a hinge joint, but rotation and gliding also occur. Condyles of femur and of tibia, and patella.

Articular capsule, attached posteriorly to intercondyloid line of femur, and the bone immediately proximal to condyles ; laterally to epicondyle, immediately proximal to popliteal groove ; medially to epicondyle, distal to adductor tubercle ; attached distally to tibia, $\frac{1}{8}$ - $\frac{1}{4}$ inch beyond margins of articular surfaces of condyles. *Fibrous stratum* is absent anteriorly, and is replaced by patella, quadriceps femoris and lig. patellæ, but the line of reflection of synovial stratum is $\frac{1}{2}$ inch proximal to margin of articular cartilage. Fibrous stratum is pierced posteriorly by tendon of popliteus ; is strengthened by expansions from vasti and fascia lata anteriorly, from ilio-tibial tract (band) laterally, from semimembranosus and semitendinosus medially. It is supplemented further by four strong ligaments, two of which act also as tendons, and two were tendons originally :—

(1) **Lig. Patellæ.**— The middle and chief part of tendon of insertion of quadriceps femoris. Separated from skin by bursa. About 3 inches long and 1 inch broad. Attached proximally to sides of apex and rough part of posterior surface of patella, distally to smooth part and slightly to rough distal part of tuberosity of tibia ; separated by bursa from tibia, proximal to tuberosity.

(2) **Lig. Popliteum Obliquum**, a broad slip from tendon of semimembranosus extending proximally and laterally towards lateral condyle, blending with capsule.

(3) **Tibial Collateral Lig. (Int. Lateral).**— Originally the distal end of tendon of adductor magnus. Strong and flat. 4 in. long, $\frac{1}{2}$ in. broad. Attached to medial epicondyle, distal to adductor tubercle ; to medial surface of tibia for $1\frac{1}{2}$ in., close to medial margin, beginning 2 in. from proximal end of tibia. Adherent to medial meniscus of knee.

(4) **Fibular Collateral Lig. (Long Ext. Lateral).**— Probably a femoral attachment of peroneus longus originally. A strong round cord, 2 in. long, attached, on proximal side of popliteal groove, to apex of lateral epicondyle ; to head of fibula in front of its apex.

Intra-articular Structures.— (1) **Ligamenta cruciata** (crucial lig.) cross like limbs of letter X ; covered in front and at sides by synovial membrane. *Lig. cruciatum anterius*, tense in extension, extends proximally, backwards and later-

ally from ant. intercondylar fossa of tibia to post. part of medial surface of lateral condyle of femur. *Lig. cruciatum posterius*, tense in flexion, passes proximally, forwards and medially from post. intercondylar fossa and popliteal notch of tibia to ant. part of lateral surface of medial condyle of femur. It is separated from post. part of capsule merely by fatty tissue.

(2) **Menisci** (Semilunar Cartilages).—Two curved fibrocartilages, resting on peripheral parts of condyles of tibia. Distal surfaces flat, proximal concave for condyles of femur; both surfaces covered with synovial membrane. Peripheral margins, thick, convex, attached to capsule; the opposite margins are thin, concave and free. Extremities, or horns, are fibrous, and attached to tibia. *Meniscus medialis*, nearly semicircular, attached by anterior horn to anterior part of ant. intercondylar fossa, in front of ant. cruciate ligament; by posterior horn to post. intercondylar fossa, in front of post. cruciate lig. Tibial collateral lig. is adherent to posterior part of its periphery. *Meniscus lateralis*, nearly circular, horns attached close together: ant. horn to front of intercondyloid eminence, behind and blended with ant. cruciate lig.; post. horn to back of eminence, in front of posterior end of medial meniscus; a separate slip from its posterior border joins post. cruciate lig. and is attached to medial femoral condyle. Tendon of popliteus lies between its lateral margin and capsule and fibular collateral lig., and is separated from it by synovial sheath.

Ligamentum transversum genu, a variable bundle, connects anterior margins of menisci. *Coronary ligaments* are the parts of the adherent capsule which connect menisci to margins of tibial condyles.

Attached to tibial intercondylar space, from before backwards, are: (1) ant. end of medial meniscus, (2) ant. cruciate lig., (3) ant. end of lateral meniscus, (4) post. end of lateral meniscus, (5) post. end of medial meniscus, (6) post. cruciate lig.

Synovial Stratum.—Very extensive and complicated. Lines capsule, except (1) where it is separated from it by *infra patellar pad of fat*, which fills interval between tibial and femoral condyles and patella; (2) where it passes on to sides and around anterior aspect of cruciate ligaments, leaving intermediate area of posterior part of capsule uncovered and separated from post. cruciate lig. merely by

areolar tissue. It extends proximally for a variable distance under cover of quadriceps, and usually communicates with supra-patellar bursa, placed still more proximally. It passes over femoral surfaces of menisci to their concave margins, and is then reflected on to their tibial surfaces. It gives a bursal sheath to intra-capsular part of popliteus. It often communicates with tibio-fibular joint, and with bursæ under heads of gastrocnemius and bursa of tendon of semimembranosus. *Plica synovialis patellaris* (lig. mucosum) is a triangular fold, containing fat, raised up from the part covering infra-patellar pad, and attached by its apex to anterior margin of intercondylar fossa of femur; its free fringed margins are called *plica alares* (ligamenta alaria).

Blood Supply.—Five articular branches of popliteal; art. genu suprema (anastomotic) of femoral; descending branch of lateral circumflex; recurrent branches of anterior tibial. **Nerves:** Branches of femoral (ant. crural) to the three vasti; three branches from tibial (int. popliteal) and two from common peroneal (ext. popliteal) accompany the five popliteal articular arteries; recurrent branch of peroneal; geniculate branch of obturator.

Relations.—**Posterior:** Oblique popliteal lig. forms middle part of floor of popliteal fossa; popliteal vessels lie on it and separate it from tibial (int. popliteal) nerve; middle articular vessels and nerve perforate it. On its lateral side plantaris partly arises from posterior part of capsule, and lateral head of gastrocnemius is partly adherent to capsule and partly separated by a bursa; common peroneal nerve (ext. popliteal) lies between lateral head and biceps. On medial side of oblique lig. the medial head of gastrocnemius is separated from posterior part of capsule by a bursa which is prolonged into interval between that head and semimembranosus tendon, as it lies on capsule, medial to gastrocnemius, and may communicate with the joint through an aperture. Semitendinosus lies on semimembranosus before turning to its insertion into medial side of tibia, and gracilis lies on postero-medial aspect of capsule, on medial side of semitendinosus. Popliteus pierces post. part of capsule, distal to lateral femoral condyle.

Medial.—Sartorius descends on posterior part of medial aspect of joint and turns anteriorly to insertion. Saphenous nerve and vessels (superficial branch of anastomotica) descend posterior to sartorius, between it and gracilis. Great saphenous vein ascends more superficially. Gracilis and semitendinosus, inclining anteriorly to their insertions, lie on tibial collateral lig., distal to line of joint. All three tendons are separated from lig. by bursa. Tibial

collateral lig., distal to line of joint, covers (1) part of semimembranosus as it lies with its bursa in groove on medial tibial condyle; and distal to that, (2) the medial inferior articular vessels and nerve.

Lateral.—Biceps covers fibular collateral lig., a bursa intervening, and is split by it longitudinally. Under cover of the ligament are: (1) the lateral inferior articular vessels and nerve of knee; (2) tendon of popliteus, which is enclosed in a bursal prolongation of synovial stratum of joint, and separates lig. from lateral meniscus (semilunar cartilage).

Anterior.—Subcutaneous bursæ, superficial vessels, patellar plexus of nerves.

Bursæ around Knee-joint.—(1) Between lateral head of gastrocnemius and capsule of joint. (2) Under cover of medial head of gastrocnemius, and between it and semimembranosus. (3) Under cover of and between sartorius, gracilis and semitendinosus, separating them from tibial collateral lig. (4) Around tendon of semimembranosus, as it lies between tibia and tibial collateral lig. (5) Between tendon of biceps and fibular collateral lig. (6) Ensheathing tendon of popliteus. (7) Patellar bursæ: (a) Between skin and distal part of patella. (b) Between the skin and lig. patella. (c) Between fascia and insertion of quadriceps into proximal border of patella. (d) Between periosteum of patella and some fibres of quadriceps which pass superficial to patella to join the lig. patella. (e) Between quadriceps and femur, proximal to knee joint. (f) Between lig. patella and tibia.

Movements. **Flexion**, *produced* by biceps, semitendinosus, semimembranosus, popliteus, gastrocnemius, plantaris, sartorius, and gracilis; *checked* by contact of leg and thigh, while lig. patella and posterior cruciate lig. are tense. Flexion is initiated and accompanied by medial rotation of tibia on femur (or lateral rotation of femur on tibia). The initial rotation is effected by popliteus, which is assisted afterwards by semitendinosus, semimembranosus, sartorius, and gracilis. **Extension**, accompanied by and terminating in lateral rotation of tibia on femur, is *produced* by quadriceps extensor, *checked* by tension of post. part of capsule, collateral and anterior cruciate ligaments.

Rotation, apart from that associated with flexion and extension, is most free when knee is flexed at right angles: **Medial rotation**, *produced* by popliteus, semitendinosus, and slightly by semimembranosus, gracilis, sartorius; *checked* by ant. cruciate ligament. **Lateral rotation**, *produced* by biceps, *checked* by tibial collateral ligament. In flexion and extension the femur moves on tibia and menisci; in rotation the movement is on that plane, and also between tibia and menisci.

Extended position is maintained, in erect posture, by gravity, and a

line dropped from centre of gravity of body falls in front of axis of knees. It has been argued that this line falls behind knees, as well as behind axis of hip-joints, but extended position is nevertheless maintained, because knee cannot be flexed without previous or concomitant flexion of hip, which is kept extended by gravity (see Hip-joint); and as long as ilio-femoral lig. is tense the lateral rotation of femur at knee, which must precede flexion, cannot occur.

During flexion and extension the femur not only rotates but glides over tibial condyles, like a cart-wheel hampered by a skid.

The patella is movable when limb is in extended position. It is said that while the limb is extended the distal pair of facets on patella is in contact with patellar surface of femur. As flexion proceeds the middle and proximal pairs, successively, are in contact; and, finally, at full flexion the patellar surface is covered only by quadriceps, and may be felt through it. (The last statement is easily verified.) It is said, further, that the medial vertical facet of patella is always in contact, and at full flexion articulates with a semilunar area on medial condyle at the side and front of intercondylar notch, while lateral proximal facet is still slightly in contact with lateral part of patellar surface; and that three facets, therefore, are always in contact, except in extreme flexion.

Articulatio Tibio-fibularis (Superior Tibio-fibular Joint).

—Diarthrodial. Gliding. Head of fibula and facet on postero-inferior aspect of lateral condyle of tibia.

Articular capsule surrounds it, and is strengthened anteriorly and posteriorly. Popliteus is posterior to it, and tendon of biceps is on proximal side and in front. Its synovial cavity may communicate with that of knee-joint. It is supplied by nerve to popliteus.

Membrana Interossea.—Attached to interosseous crests of tibia and fibula. Connected proximally with capsule of tibio-fibular joint, distally with interosseous tibio-fibular ligament. Wider proximally than distally. Fibres are directed chiefly distally and laterally.

It is perforated near proximal end by anterior tibial vessels, near distal end by perforating branches of peroneal vessels. Tibialis posterior and flexor hallucis longus arise from its *posterior surface*. Tibialis anterior, exts. digitorum longus and hallucis longus, and peronæus tertius arise from *anterior surface*, and anterior tibial vessels and deep peroneal (ant. tibial) nerve lie on it.

Syndesmosis Tibio-fibularis.—Distal ends of tibia and fibula.

Interosseous Ligament.—Short and very strong. Attached to

fibular notch of tibia and to rough triangle proximal to articular surface of lateral malleolus. **Anterior and posterior ligaments of lateral malleolus** are attached to lateral malleolus and distal end of tibia, in front of and behind interosseous ligament. Tendon of peroneus tertius crosses the anterior. Flex. hallucis longus and peroneus brevis overlap the posterior, and peroneal artery crosses it. **Inferior transverse ligament** is attached along whole length of posterior border of distal end of tibia and to the pit on lateral malleolus. Its deep surface is in contact with tibial articular surface of talus.

Articulatio Talo-cruralis (Ankle-joint).—Diarthrodial, ginglymus. Malleoli and distal surface of tibia with talus.

Thin anterior and posterior parts of *fibrous stratum of articular capsule*, which surrounds joint, are called anterior and posterior ligaments; medial and lateral parts are strengthened by specially-named accessory ligaments.

Anterior ligament, thin and broad, is attached to anterior border of distal end of tibia and to upper surface of anterior part of neck of talus (astr. talus). **Posterior ligament**, thin and sometimes defective, is attached proximally to posterior border of distal end of tibia and to inferior transverse ligament; distally to talus behind superior articular surface.

Deltoid ligament, on medial side, very strong. Narrow proximally and attached to medial malleolus; broad distally and attached, from before backward, to tuberosity of navicular, plantar calcaneo-navicular ligament, neck of talus, sustentaculum tali, body of talus + trigulus.

Lateral ligament consists of 3 bands: (1) *Ant. talo-fibular lig.* (ant. band of ext. lateral), short and flat, extends forwards and medially from anterior aspect of lateral malleolus to lateral side of neck of talus. (2) *Calcaneo-fibular lig.* (middle band of ext. lateral), long and round, extends from tip of malleolus downwards and backwards to lateral surface of calcaneus about its middle. (3) *Post. talo-fibular lig.* (post. band of ext. lateral), the strongest, extends horizontally, in a medial direction, from pit on medial aspect of lateral malleolus to posterior process of talus.

Synovial stratum lines fibrous capsule and is often projected proximally for a short distance between tibia and fibula.

Blood supply from anterior and posterior tibial and peroneal. **Nerves** from tibial and deep peroneal (ant. tibial).

Relations.—**Anterior**: From medial to lateral side: tibialis anterior, extensor hallucis longus, anterior tibial vessels (descending

dorsalis pedis, deep peroneal nerve (ant. tibial), ext. dig. longus and peroneus tertius; perforating branch of peroneal vessels on lateral malleolus. Medial end of proximal limb of cruciate lig. (lower band of ant. annular) lies obliquely across joint, and more superficially are branches of superficial peroneal nerve (musculo-cutaneous), superficial vessels; and great saphenous vein and saphenous nerve on medial malleolus.

Medial.—Tibialis posterior lies on deltoid lig. above sustentaculum tali, and flex. dig. longus on attachment of lig. to sustentaculum. Lig. laciniatum (int. annular) overlies the tendons.

Posterior.—Tendo calcaneus (Achillis) is separated from posterior lig. by a wide interval containing areolar tissue, fat, and small vessels. On medial side of tendo calcaneus, and close to the joint, are flexor hallucis longus, tibial nerve, post. tibial vessels, flex. digitorum longus, as it slips off tibialis posterior—enumerated in that order latero-medially. Vessels and nerves are on a slightly more superficial plane than the two flexors, and overlap them; and all are strapped down by lig. laciniatum (int. annular). Tendons of peroneus longus and brevis are on same plane as these, but are lateral to tendo calcaneus and on post. surface of lateral malleolus; peroneal vessels descend along the medial side of brevis.

Lateral.—As peronei tendons pass from malleolus the brevis lies on posterior talo-fibular lig. (post. band of lat. lig.) and separates longus from it. Tendons are held down by retinaculum, and have common synovial sheath. As they turn forwards below malleolus they lie on calcaneo-fibular lig. (middle band), brevis above longus, and common sheath divides to enclose them separately. Peroneus tertius crosses anterior talo-fibular lig. (ant. band). Termination of peroneal art. anastomoses with its perforating branch on this side of joint. More superficially are the small saphenous vein and the nervus suralis (short saphenous).

Movements.—**Flexion**, or dorsiflexion, *produced* by tibialis anterior, peroneus tertius, long extensors; *checked* by posterior talo-fibular, calcaneo-fibular, and posterior part of deltoid ligament, and by locking of bones. **Extension**, or plantar flexion, *i.e.* pointing the toes, *produced* by gastrocnemius, soleus, plantaris, tibialis posterior, peroneus longus and brevis, and long flexors; *checked* by ant. ligament, ant. part of deltoid lig., and ant. talo-fibular lig.

ARTICULATIONES PEDIS

Articulatio Talo-calcanea.—Diarthrodial. Gliding. Body of talus (astragalus) and dorsal surface of calcaneus (os calcis). **Articular capsule** surrounds articular surfaces, and its fibrous stratum is divided into *anterior, posterior, medial,* and *lateral portions*, of which the posterior is the weakest.

Articulatio Talo - calcaneo - navicularis.—Diarthrodial. Gliding and slight rotation. Head and lower surface of neck of talus received into socket formed by (1) navicular bone, (2) plantar calcaneo-navicular spring ligament, (3) calcaneo-navicular part of lig. bifurcatum, (4) sustentaculum tali and anterior part of dorsal surface of calcaneus.

Ligaments connected with it are the plantar calcaneo-navicular, dorsal talo-navicular, calcaneo-navicular part of lig. bifurcatum; and a thin membrane posteriorly completes the capsule and is attached above to posterior edge of smaller facet on lower surface of talus and to calcaneus below.

Lig. Talo-calcaneum Interosseum. About 1 inch broad; occupies sinus tarsi and is attached to deep grooves on contiguous surfaces of talus and calcaneus, and is chief bond of union between them. Lies between talo-calcanean capsule posteriorly and post. part of talo-calcaneo-navicular capsule anteriorly, with both of which it may be fused.

Plantar Calcaneo-navicular Ligament Inferior Calcaneo-scaphoid or "Spring" Lig. Broad and thick. One of the most important in foot. Attached to anterior margin of sustentaculum tali and to plantar surface of navicular. Head of talus rests on it. Deltoid ligament is attached to its medial edge. Tibialis posterior tendon, with its bursal sheath, covers and supports the greater part of its plantar surface, while flex. hallucis longus tendon is separated from lateral part of its plantar surface only by loose areolar tissue, and is crossed there by tendon of flex. dig. longus.

Dorsal talo navicular lig., Broad and thin, is attached to dorsal surfaces of navicular and of neck of talus. It is covered by tendons of tibialis anterior and long extensors, dorsalis pedis artery, and deep peroneal (ant. tibial) nerve. **Lig. bifurcatum**, a V- or Y-shaped ligament, attached by stem to dorsal surface of calcaneus, immediately in front of sustentaculum; by medial limb (*ant. talar or navicular part*) to lateral surface of navicular; by lateral limb (*calcaneo-cuboid part*) to medial surface of cuboid.

Articulatio Calcaneo-cuboidea.—Diarthrodial. Gliding and slight rotation. Anterior surface of calcaneus with post. surface of cuboid. **Articular capsule** is strengthened by (1) *calcaneo-cuboid part* of **lig. bifurcatum** (see above), (2) **Dorsal calcaneo-cuboid ligament**, broad and thin, unites dorsal and lateral surfaces of calcaneus to dorsal surface of cuboid; tendons of peroneus tertius and brevis lie on it. (3) **Plantar calcaneo cuboid lig.** short plantar, broad and thick. Attached to ant. part of plantar surface

of calcaneus, and to plantar surface of cuboid, behind the ridge. Long plantar ligament covers all but its medial edge.

Long plantar ligament is accessory to calcaneo-cuboid joint, and is of importance in maintaining arch of foot. Attached posteriorly to plantar surface of calcaneus over an area about an inch square, in front of tuber calcanei; anteriorly to margins of groove on cuboid, and by slips to bases of 2nd, 3rd, and 4th metatarsals. It converts the groove into a canal for peronæus longus tendon, which it provides with a fibrous sheath. It covers other plantar ligaments, and is covered by quadratus plantæ, adductor hallucis, flexor dig. quinti brevis, which all arise from it.

Talo-navicular and calcaneo-cuboid joints do not communicate, but they lie in line with one another, and the term **transverse tarsal joint** is sometimes applied to them. They lie in a line drawn from a point just behind tuberosity of navicular to a point $\frac{1}{2}$ inch behind prominent base of 5th metatarsal.

Dorsal and plantar ligaments unite navicular to the 3 cuneiforms. **Dorsal, plantar and interosseous ligaments** unite cuboid to navicular and to 3rd cuneiform, and the 3 cuneiform bones to each other.

Articulationes Tarsometatarseæ.—First metatarsal is united to first cuneiform by **articular capsule**. Other metatarsals are united to cuneiforms and cuboid by **dorsal, plantar and interosseous ligaments**. 2nd metatarsal articulates with 2nd cuneiform, and, by the sides of its base, with 1st and 3rd cuneiforms. 3rd metatarsal articulates with 3rd cuneiform; 4th and 5th with cuboid; 4th, by medial side of base, with 3rd cuneiform also. 1st, 3rd, 4th, 5th tarso-metatarsal joints lie in or near a line drawn between bases of 1st and 5th metatarsals; but 2nd joint is $\frac{1}{2}$ inch posterior to level of 1st.

Articulationes Intermetatarseæ.—Base of 1st is separate. Bases of the other four articulate and are connected by **dorsal, plantar and interosseous ligaments**.

Synovial Strata or Membranes.—Five, and sometimes six, separate synovial cavities are found in tarsal and tarso-metatarsal joints. (1) Talo-calcanean. (2) Talo-calcaneo-navicular. (3) Calcaneo-cuboid. (4) First tarso-metatarsal. (5) The other joints have a common synovial stratum, but (6) cubo-metatarsal joint may be separate.

Movements.—Gliding movements take place between all tarsal bones, but most important movements are: (1) **Inversion**, *i.e.* raising medial border of foot so that sole looks towards

opposite side : *produced* mainly by tibialis anterior and posterior, aided by flexors of toes. 2) **Eversion**, *i.e.* raising lateral border of foot so that sole looks laterally : *produced* mainly by peronei, longus, brevis and tertius, aided by ext. dig. longus. These movements take place chiefly at talo-calcaneal and transverse tarsal joints. The movements at other joints are very limited.

Metatarso-phalangeal joints and joints of the digits are comparable to corresponding joints of upper limb, except that (1) *transverse metatarsal ligament* connects all five digits, instead of only four as in hand ; and (2) toes are abducted and adducted from and to middle line of second digit, instead of third as in hand.

ARCHES OF THE FOOT

Arches of the Foot. In order that the weight of the body may be better distributed, the foot is raised up into the form of a half-dome with longitudinal and transverse arches.

Longitudinal arch.—Keystone is the talus, which receives weight of body. Posterior pillar is calcaneus. Anterior pillar is divided into navicular, three cuneiforms and first three metatarsals medially, and cuboid and last two metatarsals laterally. **Transverse arch**, or series of arches, comprises all these bones.

Arches are maintained by :—(1) Muscles and tendons around foot, especially tibialis posterior and peroneus longus ; *this is their chief support*. Tendon of peroneus longus runs forwards and medially from lateral to medial side of foot ; widespread tendons of tibialis posterior pass from medial border forwards and laterally. They therefore brace up both longitudinal and transverse arches. (2) Form of the bones. (3) All ligaments, especially plantar calcaneo-navicular, calcaneo-cuboid, and long plantar. (4) Fasciae, especially plantar aponeurosis.

The functions of the arches of foot are :—(1) To distribute the weight of the body. (2) To give spring and elasticity to the step. (3) To break shocks, in running and jumping. (4) To provide a space where soft parts of sole may lie free from undue pressure.

MUSCLES AND FASCIÆ

Superficial fascia is a continuous sheet of areolar tissue containing fat—*panniculus adiposus*—underlying skin over whole body. Cutaneous vessels and nerves traverse it on their way to and from the skin. Fat is absent from it under skin of eyelids, penis, scrotum, and labia minora, and in nipple and areola of mammary gland. It is very firm and dense on soles, palms and scalp. Its deeper part is fibrous; and in perinæum, lower part of abdomen, and proximal part of front of thigh the fibrous and fatty parts are in distinct layers.

Deep fascia is a dense, strong, fibrous, bluish membrane, under superficial fascia. Covers muscles. Attached to subcutaneous bony points and to ligaments of joints. Thickened in region of some joints, *e.g.* wrist and ankle, to bind down tendons in their places. Provides attachment for muscles in some cases. Sends septa in among tissues to ensheath muscles, vessels, nerves and glands.

Muscles are the means by which movements are brought about. They form the red flesh of the body. They are attached to bones, cartilages, ligaments, deep fascia and skin. Attachment may be by muscular tissue, but is usually by fibrous tissue called **tendon**. Some tendons are in the form of strong fibrous cords. When tendinous attachment forms a broad sheet it is called an **aponeurosis**. Aponeurosis sometimes replaces deep fascia, *e.g.* lumbo-dorsal fascia. Muscles are attached by at least two ends. These attachments are called origin and insertion. **Origin** is the attachment which remains stationary when the muscle contracts. It is usually the proximal and more extensive attachment. **Insertion** is the attachment which moves when the muscle contracts. Some muscles can act in either direction, the "origin" on some occasions being the attachment that is moved, *e.g.* muscles which commonly draw arm to trunk, draw trunk to arm in climbing. Muscles act on all joints which they cross, beginning with the one nearest insertion; and their actions can usually be inferred from their attachments and their relations to the

joints. Each muscle is supplied by one or more nerves, which convey motor impulses to it and sensory impressions from it. Each is supplied with blood by numerous branches from neighbouring blood vessels.

Bursæ mucosæ are fibrous sacs lined with mucous or synovial membrane, which secretes a viscid fluid like synovia. They are found between skin and subcutaneous bony points, under muscles and tendons passing over bones or ligaments, and between tendons or muscles. They facilitate movement. **Vaginæ mucosæ**, or **synovial sheaths**, resemble bursæ in structure. They enclose tendons. Some bursæ and synovial sheaths are prolongations of synovial strata (membranes) of joints.

MUSCLES AND FASCLE OF SUPERIOR EXTREMITY

MUSCLES WHICH CONNECT SUPERIOR EXTREMITY TO TRUNK

Trapezius lies superficially, on back of neck and of upper part of trunk. **Origin**, tendinous: medial $\frac{1}{3}$ of superior nuchal line, ext. occipital protuberance, lig. nuchæ, spines of 7th cervical and all thoracic vertebrae, supra-spinous ligaments. **Insertion**, fleshy and tendinous: posterior border of lateral $\frac{1}{3}$ of clavicle, encroaching on upper surface; medial margin of acromion; upper lip, and tubercle on lower lip, of dorsal border (crest) of spine of scapula. **Nerves**: anterior rami of 3rd and 4th cervical, and accessory.

Whole muscle braces back shoulder; upper fibres elevate, lower depress. Middle and lower fibres rotate scapula so that, after arm has been abducted to a right angle by deltoid, it is directed straight upwards. When shoulder is fixed upper fibres draw head to that side, and both muscles acting retract head. Bursa lies between tendon of lower part and root of spine of scapula.

Latissimus dorsi lies in lower part of back and lower part of posterior wall of axilla. **Origin**, very broad: by means of lumbo-dorsal fascia from spines and supra-spinous ligaments of lower 6 thoracic, the lumbar and upper sacral vertebrae, and posterior part of iliac crest; by fleshy fibres from iliac crest a little posterior to its middle, from lower 3 or 4 ribs and, sometimes, inferior angle of scapula. **Insertion** by flat tendon into bottom of intertubercular bicipital groove

of humerus, and into fascia of arm. **Nerve**: C. 6, 7, 8, through thoraco-dorsal (long subscapular).¹

It adducts, extends and rotates humerus medially; when arm is fixed it can raise lower ribs, and assists in drawing trunk forwards and upwards. It winds round teres major, assisting it to form lower part of posterior wall of axilla; it is separated from teres major, at insertion, by a bursa.

Triangle of Auscultation.—Bounded by trapezius, latissimus and vertebral border of scapula. Floor is formed by rhomboideus major, and, when scapula is drawn forwards, by 6th and 7th ribs also,—the only part of ribs uncovered by muscles.

Levator scapulæ lies at back of side of neck. **Origin**: tendinous slips from posterior aspect of transverse processes of 1st and 2nd cervical vertebrae, and posterior tubercles of transverse processes of 3rd and 4th. **Insertion** (fl.-tend.)²: vertebral margin of scapula, from medial angle to root of spine. **Nerve**: C. 3 and 4 directly; and C. 5, through dorsalis scapulæ (nerve to rhomboids). It assists trapezius in raising shoulder and bracing it against weights.

Rhomboideus minor lies in upper part of back. **Origin** (fl.-tend.): lig. nuchæ, spines of 7th cervical and 1st thoracic vertebrae. **Insertion**: vertebral margin of scapula, at root of spine. **Rhomboideus major** lies in upper part of back, under trapezius. **Origin**: 2nd to 5th thoracic spines and supraspinous ligaments. **Insertion**: vertebral margin of scapula, from root of spine to inferior angle, lowest fibres directly to scapula, remainder to a fibrous band attached by its ends to root of spine and inferior angle. **Nerve**: C. 5, through dorsalis scapulæ (nerve to rhomboids). They retract and rotate scapula.

Pectoralis major lies superficially, on anterior aspect of chest and in ant. wall of axilla. It is largely covered by mammary gland, and separated from deltoid by a groove containing cephalic vein and deltoid branch of thoraco-acromial art. **Origin** (fl.): *clavicular part* from anterior surface of medial half of clavicle; *costo-sternal part* from anterior surface of sternum, upper 6 costal cartilages and aponeurosis of obliquus externus abdominis. Costo-sternal part is twisted, lowest fibres curving upwards posterior to upper fibres, so that a *bilaminar tendon* is formed. Clavicular fibres join its anterior

¹ C. signifies cervical.

² (fl.) signifies fleshy, (tend.) tendinous, (fl.-tend.) fleshy and tendinous.

lamina. **Insertion** : lateral lip of intertubercular (bicipital) sulcus, with expansions to capsule of shoulder and fascia of arm. **Nerves** : C. 5, 6, 7, through lateral anterior thoracic ; C. 7, 8, T. 1, through medial anterior thoracic.

It flexes, adducts arm, and rotates it medially. When arm is fixed it can raise ribs, and draw trunk to arm.

Pectoralis minor lies on anterior wall of chest and in ant. wall of axilla, under cover of pectoralis major. **Origin** (fl.) : 2nd, 3rd, 4th, 5th ribs, near cartilages usually omitting 2nd or 5th. **Insertion** tend. : medial border and upper surface of distal $\frac{1}{2}$ of coracoid process, and into conjoined tendon of coraco-brachialis and biceps. **Nerve** : C. 7, 8, T. 1, through medial anterior thoracic.¹ It draws shoulder downwards and forwards ; raises ribs when shoulder is fixed.

Subclavius lies between clavicle and 1st rib. **Origin** : by tendon, from junction of 1st rib and cartilage, anterior to costo-clavicular ligament. **Insertion** fl. : groove on lower surface of middle $\frac{2}{3}$ of clavicle. **Nerve** : n. to subclavius from C. 5, 6. It draws clavicle downwards and anteriorly. Subclavian vessels lie posterior to it and below it.

Fascia Coraco-clavicularis (Costo-coracoid Membrane). Lies posterior to clavicular part of pectoralis major, anterior to 1st part of axillary vessels. *Above*, it splits to enclose subclavius and to be attached to lips of groove on clavicle for subclavius. *Below*, it splits to enclose pectoralis minor, from which it is continued into axillary fascia. Attached *medially* to 1st costal cartilage and fascia of 1st intercostal muscle, *laterally* to coracoid process. Deep surface is connected with sheath of axillary vessels. It is *pierced* by thoraco-acromial vessels, cephalic vein, lateral anterior thoracic nerve. **Costo coracoid ligament** is a thickened part of it, between 1st cartilage and coracoid process.

Axillary fascia forms floor of axilla. Continuous with fascia covering pectoralis major anteriorly, latissimus dorsi and teres major posteriorly, serratus anterior medially, fascia of arm laterally. Deep surface is connected with fascia of pectoralis minor, traction of which on axillary fascia produces hollow of armpit when arm is raised.

Serratus anterior (s. magnus) lies on side of chest, and forms medial wall of axilla. Infero-lateral quadrant of mammary gland lies on it. First digitation appears, above clavicle, in posterior triangle of neck. **Origin** (fl.) : by 8 digitations from upper 8 ribs and fascia covering intercostal

¹ T. 1, or T. 2, signifies thoracic.

muscles. First digitation arises from both 1st and 2nd ribs. **Insertion** (fl.-tend.): 1st digitation into ventral surface of medial angle of scapula; 2nd, 3rd, 4th into strip on ventral aspect of vertebral margin; 5th, 6th, 7th, 8th converge upon ventral surface of inferior angle. **Nerve**: C. 5, 6, 7, through long thoracic (Bell).

It draws scapula forwards, in pushing and in blow from shoulder; after arm has been flexed, *i.e.* when directed horizontally forwards, the serratus rotates scapula so that arm is directed upwards; and it steadies scapula while trapezius is rotating scapula to direct arm upwards, after it has been abducted to the horizontal. Elevates middle ribs when scapula is fixed.

MUSCLES CONNECTING SHOULDER GIRDLE WITH HUMERUS

Deltoid surrounds shoulder superficially. **Origin** (fl.-tend.) corresponds to insertion of trapezius: anterior border of lateral $\frac{1}{3}$ of clavicle, lateral margin of acromion, lower lip of crest of spine of scapula. **Insertion** (tend.): deltoid tuberosity on middle of lateral surface of humerus. **Nerve**: C. 5, 6, through axillary (circumflex).

It moves arm to a right angle with trunk. Whole muscle abducts; anterior fibres flex and rotate medially; posterior fibres extend and rotate laterally.

Structures covered by Deltoid.—**Anteriorly**: Coracoid process, coraco-clavicular ligament, insertion of pectoralis minor; origin of short head of biceps and coraco-brachialis, which separate it from subscapularis; long head of biceps, insertion of pectoralis major. **Laterally**: Coraco-acromial ligament; a large bursa which separates it from greater tubercle (tuberosity) and tendons of supra- and infraspinatus; surgical neck and proximal part of shaft of humerus, on which lie posterior circumflex vessels and axillary (circumflex) nerve. **Posteriorly**: Infraspinatus, teres minor and major, quadrilateral space and its contents, long and lateral heads of triceps.

It is nowhere in contact with capsule of shoulder-joint, but is separated from it by subacromial bursa and the muscles attached to tubercles (tuberosities) and coracoid process.

Supraspinatus lies in supra-spinous fossa and on top of capsule of shoulder, under cover of trapezius, coraco-acromial arch and deltoid. **Origin** (fl.): supra-spinous fossa, except

near neck of scapula, and from fascia covering it. **Insertion** : by tendon into upper impression on greater tubercle (tuberosity) of humerus and into joint capsule. **Nerve** : C. 5, 6, through supra-scapular. It abducts arm.

Infraspinatus lies in infra-spinous fossa and under cover of deltoid, on superior and posterior surface of capsule of shoulder, a bursa sometimes intervening. **Origin** (fl.) : infra-spinous fossa, except near neck, and from fascia covering it. **Insertion** : by tendon into middle impression of greater tubercle and into joint capsule. **Nerve** : C. 5, 6, through supra-scapular. It extends arm and rotates it laterally.

Teres minor lies along lower border of infraspinatus, and on posterior surface of capsule of shoulder. **Origin** (fl.) : elongated elevation on dorsal surface of scapula, along axillary margin. **Insertion** : by tendon into posterior impression on greater tubercle (tuberosity) of humerus and slightly into shoulder-joint capsule ; by fleshy fibres into surgical neck and shaft of humerus for nearly an inch. **Nerve** : C. 5, 6, through axillary (circumflex).

It rotates arm laterally, and adducts and extends it.

Teres major lies in lower border of posterior wall of axilla. Latissimus dorsi, at first posterior to it, curves below it to lie anterior to its insertion, from which it is separated by bursa. **Origin** (il.) : oval elevation on dorsum of scapula, above inferior angle. **Insertion** : by tendon into medial lip of intertubercular (bicipital) groove of humerus. **Nerve** : C. 5, 6, through lower subscapular.

It extends and adducts arm, and rotates it medially.

Subscapularis lies in posterior wall of axilla and on anterior aspect of capsule of shoulder-joint, from which it is partly separated by bursa which protrudes from joint. **Origin** (il.) : subscapular fossa, including groove along axillary margin of scapula, but excluding portion near neck, and portions occupied by insertion of serratus anterior ; also from tendinous septa which pass into its substance from ridges in fossa. **Insertion** : by tendon into lesser tubercle (tuberosity) of humerus, by fleshy fibres into surgical neck and shaft for nearly an inch. **Nerves** : C. 5, 6, through upper and lower subscapular.

It adducts arm, and rotates it medially, and possibly flexes it.

Coraco-brachialis. See Muscles of Arm, p. 137.

Quadrilateral Space.—*Bounded above* by subscapularis, capsule of shoulder-joint, teres minor; *below* by teres major; *laterally* by shaft of humerus and lateral head of triceps; *medially* by long head of triceps. *Transmits* axillary (circumflex) n. and post. circumflex vessels. *Covered* posteriorly by deltoid; related anteriorly to coraco-brachialis and biceps, and large vessels and nerves in axilla.

Triangular Space.—*Bounded above* by subscapularis, axillary margin of scapula, teres minor; *below* by teres major; *laterally* by long head of triceps. Circumflex scapular artery (dorsalis scapulæ) is seen in it.

Axilla or Armpit.—**Anterior wall:** pectoralis major and minor, costo-coracoid membrane. **Posterior,** longer from above downwards than anterior: subscapularis, teres major, latissimus dorsi. **Medial:** upper 4 or 5 ribs and intervening spaces, covered by serratus anterior (magnus). **Lateral,** very narrow: coraco-brachialis, biceps. **Base,** axillary fascia. **Apex** leads up into posterior triangle of neck, through cervico-axillary canal, which is bounded *anteriorly* by clavicle, *posteriorly* by upper border of scapula, *medially* by first rib. **Contents:** axillary vessels and their branches; lower part of brachial plexus and its branches: long thoracic nerve; intercosto-brachial nerve, lateral cutaneous branches of 3rd and 4th intercostal nerves; termination of cephalic vein; lymphatic glands and vessels, areolar tissue and fat. Axillary vessels, brachial plexus and its large branches lie close to the lateral wall of axilla, except at the apex, and follow it when arm is moved; and in upper part of axilla they are closer to anterior wall than to the posterior.

Relations in Axilla

(Some of the structures are followed beyond the axilla.)

Axillary vessels and brachial plexus are enveloped in a sheath continued over them from prevertebral cervical fascia.

Axillary artery begins as a continuation of subclavian at outer margin of 1st rib, where it enters axilla through its apex; and it ends by becoming continuous with brachial at lower border of teres major tendon, where it leaves axilla. When arm is dependent, it is slightly arched with convexity upwards and laterally; when arm is abducted to a right angle, the artery is straightened out and lies opposite a line drawn from centre of clavicle to junction of arm with lower border of posterior wall of axilla. Pectoralis minor, as it crosses anterior to the artery, divides it into 3 parts—1st part above it, 2nd part posterior to it, 3rd part below it. First part gives off the art. thoracalis suprema. Second part gives off thoraco-acromial (thoracic axis), lateral thoracic, alar thoracic. Third part gives off subscapular, ant. and post. humeral circumflex.

Relations of 1st Part.—*Anterior,* from skin towards axilla:

skin, superficial fascia, platysma, middle supra-clavicular nerves; deep fascia; pectoralis major; lateral anterior thoracic nerve and branches of thoraco-acromial artery (thoracic axis) and cephalic vein; costo-coracoid membrane; loop between ant. thoracic nerves. *Lateral and above*: lateral and posterior cords of plexus, lateral anterior thoracic nerve. *Posterior*: medial cord of plexus and medial anterior thoracic nerve; long thoracic nerve, contents of 1st intercostal space and first digitation of serratus anterior (magnus). *Medial and below*: axillary vein and medial anterior thoracic nerve passing anteriorly between artery and vein.

Relations of 2nd Part.—*Anterior*: skin, etc., pectoralis major and minor. *Lateral*: lateral cord of plexus. *Posterior*: posterior cord, and, posterior to that, fatty areolar tissue separating it from subscapularis. *Medial*: axillary vein, and medial cord between artery and vein.

Relations of 3rd Part.—*Anterior*: skin, fascia, and pectoralis major proximally, skin and fascia distally. Lateral vein comes crossing to join medial; medial head of median nerve, medial cutaneous nerve of forearm (int. cutaneous); axillary vein overlaps. *Lateral*: median and musculo-cutaneous nerves; coraco-brachialis. *Posterior*: subscapularis, latissimus dorsi, teres major, from above downwards, subscapularis chiefly. radial nerve (musculo-spiral) between artery and all three muscles, axillary nerve (circumflex) between art. and subscapularis. *Medial*: axillary vein, medial vein comes, and ulnar nerve between artery and vein, medial cutaneous nerve of arm (lesser int. cutaneous) on medial side of vein.

Axillary vein begins at lower border of teres major as a continuation of basilic vein; passes upwards and medially, on medial side of artery, to end at outer border of 1st rib by becoming subclavian. It possesses several valves.

Relations.—*Anterior*: skin, etc., pectoralis major, branches of thoraco-acromial artery (thoracic axis), and of medial anterior thoracic nerve; pect. minor and costo-coracoid membrane. *Lateral*: axillary artery, medial anterior thoracic nerve between vein and 1st part of artery, medial cord between it and 2nd part, ulnar nerve deeply between it and the 3rd part. *Posterior*: first digitation of serratus anterior (magnus), subscapularis, latissimus dorsi, teres major, long thoracic nerve, art. thoracalis suprema, lateral thoracic art., medial cutaneous nerve of arm (lesser int. cutaneous), subscapular art. and nerves, thoraco-dorsal nerve (long subscapular). *Medial*: lymph glands; medial cutaneous nerve of arm (lesser int. cutaneous).

Tributaries—(1) V. comites of branches of axillary artery. (2) V. comites of brachial artery are continued along axillary, the lateral one crossing obliquely over the 3rd part and they join axillary vein at lower border of subscapularis. (3) Proximal part of cephalic vein pierces deep fascia, ascends in groove between pectoralis major and deltoid; below clavicle it passes under cover of clavicular head

of pectoralis major, crosses pectoralis minor, pierces costo-coracoid membrane, crossing anterior to 1st part of axillary artery, and ends in axillary vein.

Branches of Axillary Artery.—(1) **Art. thoracalis suprema** arises from 1st part and crosses superficial or deep to axillary vein, to ramify over 1st intercostal muscle. (2) **Thoraco-acromial art.** (thoracic axis) arises from 2nd part, turns over upper border of pectoralis minor, pierces costo-coracoid membrane, divides into acromial, clavicular, deltoid, and pectoral branches, which diverge from one another; the *acromial* laterally over pect. minor and coracoid process, piercing deltoid to reach acromion; the *clavicular* medially along clavicle, posterior to pect. major; the *deltoid* distally between pect. major and deltoid; the *pectoral* downwards and medially between pectorales, anastomosing with lateral thoracic and intercostals. (3) **Lateral thoracic** arises from second part, runs downwards and medially, posterior to axillary vein, to lower border of pect. minor, along which it runs to wall of thorax, supplying muscles, anastomosing with intercostals, and contributing some *external mammary branches* to mammary gland. (4) **Alar thoracic** consists of small irregular twigs arising from axillary artery or its branches to supply fat and lymph glands.

(5) **Subscapular artery**, the largest branch of axillary, arises from 3rd part, and runs along lower border of subscapularis to inf. angle of scapula. In the first part of its course it is posterior to ulnar nerve and axillary vein, and in latter part of its course it crosses anterior to lower subscapular nerve, and is accompanied by thoraco-dorsal nerve (long subscapular). After emerging from under cover of axillary vein it gives off the **circumflexa scapulæ**, which crosses triangular space and passes under teres minor to reach dorsum of scapula. Both anastomose with branches of transverse scapular (suprascapular) and descending branch (post. scapular) of transverse cervical.

(6) **Anterior humeral circumflex artery** arises from 3rd part, and turns laterally under cover of coraco-brachialis and short head of biceps, between them and surgical neck of humerus, and sends one branch to shoulder through intertubercular (bicipital) groove; another distally in the groove, supplying pect. major tendon; and branches to muscles, including deltoid.

(7) **Posterior humeral circumflex artery**, much larger than anterior, arises opposite anterior, passes dorsally through quadrilateral space, below shoulder-joint, distal to axillary (circumflex) nerve, winds round surgical neck of humerus under cover of deltoid. Its branches supply deltoid, skin, and shoulder-joint. Its important anastomosis is with profunda branch of brachial artery.

Nerves in Axilla not arising from Brachial Plexus.—

(1) **Intercosto-brachial nerve** (intercosto-humeral) is the lateral cutaneous branch of 2nd intercostal. It pierces 2nd external intercostal muscle; appears between digitations of serratus anterior;

stretches across axilla, supplying skin of its floor; communicates with medial cutaneous nerve of arm (lesser internal cutaneous); pierces deep fascia where lateral wall of axilla joins arm, supplies skin of dorsal part of medial side of arm (O.T. upper arm).

(2) **Lateral cutaneous branches of 3rd and 4th intercostal nerves** divide, under cover of serratus anterior, into anterior and posterior divisions, which appear through or between its digitations, and leave medial wall of axilla by turning round borders of pectoralis major and latissimus dorsi respectively; posterior division of 3rd may send branches across to skin of floor of axilla and medial side of arm.

Brachial plexus lies partly in antero-inferior angle of posterior triangle of neck, partly posterior to clavicle, partly in axilla. It is made up of (i.) *Roots*—anterior branches of 5th, 6th, 7th, 8th cervical, greater part of 1st thoracic, and communications from 4th cervical and 2nd thoracic nerves; (ii.) *Trunks*—upper, middle and lower; (iii.) 3 anterior and 3 posterior *divisions*; (iv.) *Cords*—lateral, medial and posterior; (v.) *Branches*.

5th and 6th cervical, and communication from 4th, combine to form **upper trunk**; 7th alone forms **middle trunk**; 8th cervical, 1st thoracic and communication from 2nd form **lower trunk**. Each trunk divides into an anterior and a posterior division. The three posterior divisions combine to form **posterior cord**; the two upper anterior divisions unite to form **lateral cord**; the lower anterior division alone forms **medial cord**. Lateral cord therefore contains fibres of 5, 6, 7 C., medial cord 8 C., 1 TH., post. cord, 5, 6, 7, 8 C., but 1st thoracic contributes few or no fibres to post. cord. The branches arise from the roots in the neck, from the cords in the axilla. The cords, having given off lateral branches, end, each by dividing into two terminal branches, at the junction of 2nd and 3rd parts of axillary artery, opposite tip of coracoid process and opposite infero-lateral border of pectoralis minor.

Relations above Axilla.—*Superficial to it* are skin, fasciæ, platysma, supra-clavicular nerves; ext. jugular, transverse cervical and scapular (supra-scapular) veins, post. belly of omohyoid, transverse cervical artery, nerve to subclavius; prevertebral fascia and lateral border of scalenus anterior; 3rd part of subclavian art.; clavicle and subclavius, and transverse scapular art. behind clavicle. *Deep to it* are scalenus medius and roots of long thoracic nerve.

Relations in Axilla.—*Anterior to it* are skin, fasciæ, platysma, middle supra-clavicular nerves; pectoralis major; cephalic vein and branches of thoraco-acromial artery (thoracic axis); pectoralis minor and costo-coracoid membrane; axillary artery. Trunks and cords are above, lateral and posterior to 1st part of artery; cords are arranged, according to name, around 2nd part. *Posterior to it* are serratus anterior (magnus), long thoracic nerve, fat, and subscapularis.

Branches of Roots of Brachial Plexus.—*Communicating* Grev rami communicantes from sympathetic ganglia.

Muscular branches to prevertebral and scalene muscles; a root of phrenic from 5th. Dorsal scapular nerve, nerve to subclavius, supra-scapular, and long thoracic nerves.

Long thoracic nerve (Bell) is the only one to enter axilla. It arises from 5th, 6th, 7th. Roots from 5 and 6 pierce scalenus medius, root from 7 crosses anterior to it. They pass from scalenus into axilla over upper border of 1st digitation of serratus anterior, between it and 1st part of axillary artery; combine into one stem, which descends over axillary surface of serratus anterior, supplying it alone.

Branches of Cords of Brachial Plexus.—**Lateral cord** gives off lateral anterior thoracic and divides into musculo-cutaneous and lateral head of median. **Medial cord** gives off medial anterior thoracic, medial cutaneous nerve of arm (lesser int. cutaneous), medial cutaneous nerve of forearm (int. cutaneous), and divides into ulnar and medial head of median. **Posterior cord** gives off upper and lower subscapular, thoraco-dorsal (long subscapular), and divides into axillary (circumflex) and radial (musculo-spiral).

Note.—The figures inserted in brackets in the following paragraphs refer to the spinal nerves from which the nerve under description ultimately derives its fibres.

Lateral anterior thoracic nerve (5, 6, 7 C.) arises from lateral cord, runs anteriorly, lateral to 1st part of axillary artery; is connected with medial ant. thoracic by a loop placed anterior to the artery; pierces costo-coracoid membrane and sinks into upper part of pectoralis major, to supply it.

Musculo-cutaneous nerve (5, 6 C.), a terminal branch of lateral cord, runs distally between axillary artery and coraco-brachialis, and leaves axilla by piercing coraco-brachialis, opposite teres major.

Nerve to coraco-brachialis, from 7 C. or 6 and 7 C., is incorporated with it, and leaves it before it pierces coraco-brachialis.

Median nerve arises from lateral and medial cords. *Lateral head* (5, 6, 7 C.), a terminal branch of lateral cord, lies on lateral side of axillary artery; *medial head* (8 C., 1 T.), a terminal branch of medial cord, crosses anterior to the artery to join lateral head. Median nerve descends on lateral side of axillary art. between it and coraco-brachialis. It gives no branches in axilla (or in arm).

Medial anterior thoracic nerve (8 C., 1 T.) arises from medial cord, passes anteriorly between axillary artery and vein, communicates with lateral anterior thoracic, pierces pectoralis minor, supplying it, and ends in pectoralis major.

Medial cutaneous nerve of arm (lesser internal cutaneous) (1 T.) arises from medial cord, passes posterior to axillary vein to reach its medial side; descends along its medial side; pierces deep fascia to supply skin of medial side of arm (O.T. upper arm).

Medial cutaneous nerve of forearm (internal cutaneous) (8 C., 1 T.) arises from medial cord, anterior to ulnar, and runs distally on anterior surface of axillary artery. It gives off no branches in axilla.

Ulnar nerve (8 C., 1 T.), a terminal branch of medial cord, runs distally on medial side of axillary artery, between it and vein. It gives no branches in axilla (or in arm).

Subscapular nerves (5, 6 C.) arise from posterior cord. The **upper** passes downwards and backwards, posterior to medial cord and axillary vein, and sinks into upper part of subscapularis, after a very short course; the **lower** runs downwards and laterally, posterior to medial cord and axillary vein, over subscapularis, supplying its lower part, and, crossing deep to subscapular vessels, it ends in teres major.

Thoraco-dorsal nerve (long subscapular) (6, 7, 8 C.) arises from posterior cord, between upper and lower subscapulars, runs downwards and posteriorly over subscapularis and teres major towards inferior angle of scapula, where it ends in latissimus dorsi. It is posterior to the medial cord and to axillary vein, and, after appearing from under cover of them, it accompanies subscapular vessels.

Radial nerve (musculo-spiral) (5, 6, 7, 8 C. and sometimes 1 T.), the largest nerve in axilla, is a terminal branch of post. cord. It proceeds distally, posterior to axillary art., anterior to subscapularis, latissimus dorsi, and teres major. A few branches arise from it in axilla: (a) *muscular branches* are given to long and medial heads of triceps; (b) *posterior cutaneous nerve of arm* (int. cutaneous branch of musculo-spiral) turns distally and dorsally to supply skin on medial side of back of arm (O.T. upper arm).

Axillary nerve (circumflex) (5, 6 C.), a terminal branch of posterior cord, runs first distally between axillary art. and subscapularis, on lateral side of radial nerve; then it leaves axilla by passing dorsally, with posterior humeral circumflex vessels, through quadrilateral space, *i.e.* with teres major below, humerus and lateral head of triceps laterally, long head of triceps medially, subscapularis, shoulder-joint and teres minor above; while in the space, under cover of deltoid, it gives a branch to shoulder-joint and divides into anterior and posterior divisions. **Posterior division** gives branches to teres minor and deltoid, and turning round posterior border of deltoid, as *lateral cutaneous nerve of arm*, supplies skin over distal part of deltoid. **Anterior division** accompanies post. circumflex vessels around humerus under cover of deltoid; it supplies deltoid, and some branches pierce deltoid to supply skin.

Lymph glands of axilla are in three main groups: (1) **Pectoral glands** lie in the angle between pectoral muscles and serratus anterior. They receive afferent lymph vessels from mammary gland and antero-lateral walls of body above umbilicus, and send efferent vessels to axillary glands. (2) **Subscapular glands** lie along lower border of subscapularis; receive afferents from postero-lateral walls of body, above level of umbilicus, and from lower and back parts of neck; and send efferents to axillary glands. (3) **Axillary glands** lie on floor of axilla and along axillary vessels. They receive afferents directly from whole upper limb, and from cubital, pectoral, and sub-

scapular glands, their efferents pass partly to lower deep cervical glands, and partly into subclavian lymph trunk, which ends in the thoracic or right lymphatic duct, or ends independently in one of the large veins at root of neck. Those which lie on floor and in centre of axilla are sometimes called the *central group*. Those behind pectoralis minor are called *sub-pectoral*. Those above pect. minor, along medial side of artery, are called the *infra-clavicular group*, and from their efferents the subclavian trunk arises.

Delto-pectoral glands. 2 or 3, lie between pectoralis major and deltoid, and drain proximal and lateral parts of arm.

FASCIÆ AND MUSCLES OF ARM

Superficial fascia of the brachium or arm (O.T. upper arm) contains : (1) small unnamed cutaneous vessels ; (2) **cephalic vein**, in the groove on lateral side of biceps ; (3) **basilic vein**, in groove on medial side of biceps as far up as middle of arm, where it pierces deep fascia ; (4) **medial cutaneous nerve of forearm** (int. cutaneous), which pierces deep fascia at middle of arm and lies alongside basilic vein. It gives one or more branches to skin of proximal part of arm before it pierces deep fascia. (5) **Medial cutaneous nerve of arm** (lesser int. cutaneous), on proximal part of medial side of arm ; (6) **intercosto brachial nerve** (intercosto-humeral), on medial side of arm still nearer axilla ; (7) **posterior cutaneous nerve of arm** (int. cutaneous branch of musculo-spiral), passing out of axilla, across intercosto-brachial, to medial side of posterior aspect of arm. (8) **Dorsal cutaneous nerve of forearm** (upper and lower ext. cutaneous of musculo-spiral), piercing deep fascia near insertion of deltoid, the *proximal branch* to supply skin on lateral aspect of distal part of arm and the proximal part of back of forearm, the *distal* to pass to forearm ; (9) **lateral cutaneous nerve of arm** (cutaneous part of post. division of circumflex), over distal part of deltoid ; (10) **superficial cubital lymph glands**, opposite elbow, near basilic vein, and proximal to medial epicondyle.

Deep fascia completely invests arm, and is strengthened by expansions from tendons of latissimus dorsi, pectoralis major, and deltoid. It is continuous proximally with fascia of shoulder and axilla, distally with fascia of forearm, and it is also attached to olecranon and epicondyles. It gives off septa, which separate muscles from each other. Two of these are strong, and are attached to epicondyles and epicondylar ridges :—

(1) **Medial intermuscular septum**, the larger and stronger, gives origin by its anterior surface to brachialis and pronator teres, by its posterior surface to medial head of triceps. It is pierced by ulnar nerve, superior and inferior ulnar collateral vessels (inf. profunda and anastomotica).

(2) **Lateral intermuscular septum** gives origin by its anterior surface to brachio-radialis and ext. carpi radialis longus, by its post. surface to medial and lateral heads of triceps. It is pierced by radial nerve (musculo-spiral) and by radial collateral vessels (anterior branches of superior profunda artery and vein).

Coraco-brachialis lies on anterior and medial aspects of proximal part of arm and in lateral wall of axilla. It is seen as a longitudinal ridge when arm is abducted. Musculo-cutaneous nerve pierces it. **Origin** (fl.): tip of coracoid process, in company with short head of biceps, but on its medial side. **Insertion** (tend.): impression, about 1 inch long, on middle of medial margin of humerus. **Nerve**: c. 7 or c. 6, 7, through musculo-cutaneous. Flexes and adducts arm.

Biceps brachii lies superficially on anterior aspect of the arm, where it overlaps brachial vessels and median nerve. **Origin**: *Short head*, by tendon from tip of coracoid process, conjoined with coraco-brachialis and on its lateral side; lies in lateral wall of axilla. *Long head*, by long tendon, which partly arises from impression above glenoid cavity of scapula, and is partly continuous with fibres of labrum glenoidale (glenoid lig.). It traverses upper part of shoulder-joint, ensheathed in tube of synovial membrane, which accompanies it into intertubercular groove. **Insertion**: into rough dorsal part of tuberosity of radius by tendon, which is separated from smooth volar (anterior) part by bursa; and into fascia covering pronator teres by expansion from its tendon, called *lacertus fibrosus* (bicipital fascia). Both tendon and lacertus are easily felt. **Nerve**: c. 5, 6, through musculo-cutaneous.

It supinates forearm to position midway between supination and pronation, and then flexes; flexes shoulder-joint.

Brachialis lies on anterior aspect of humerus, posterior to biceps. **Origin** (fl.): anterior aspect of distal $\frac{2}{3}$ of shaft of humerus, and from medial intermuscular septum and ant. lig. of elbow. Its proximal end clasps insertion of deltoid. **Insertion** (tend.): volar (anterior) surface of coronoid process and tuberosity of ulna. **Nerves**: c. 5, 6, through musculo-cutaneous and radial (musculo-spiral). It flexes forearm.

Triceps brachii lies on posterior aspect of the arm. **Origin**: (1) *Long head*, by tendon from infra-glenoid tuberosity of scapula. It lies between teres major and minor, and between quadrilateral and triangular spaces. (2) *Lateral head* (fl.-tend.), from lateral border of humerus, proximal to groove for radial (musculo-spiral) nerve, from fibrous bridge

across the groove, and from lateral intermuscular septum. (3) *Medial head* (fl.-tend.), from post. surface of humerus from olecranon fossa to insertion of teres major, and from lateral and medial intermuscular septa. Radial (musculo-spiral) nerves run distally and laterally between long and medial heads to lie in groove, between medial and lateral heads. **Insertion** : by tendon, separated from posterior ligament of elbow by bursa, into posterior area on proximal surface of olecranon, and by expansion into fascia on each side. **Nerve** : C. 7, 8, through radial (musculo-spiral). It extends forearm ; long head extends and adducts arm.

Subanconæus consists of a few of deeper fibres of triceps which arise from distal part of posterior surface of humerus and are inserted into fibrous capsule of elbow, and pull it away during extension.

FASCIÆ AND MUSCLES OF FOREARM AND HAND

Superficial fascia of antibrachium or forearm contains : (1) small unnamed cutaneous vessels ; (2) **median vein**, along middle of volar (anterior) surface, dividing at cubital fossa into *median-basilic* and *median-cephalic* ; (3) **basilic vein**, along ulnar border ; (4) **cephalic vein**, along radial border ; (5) volar and dorsal branches of **musculo-cutaneous nerve**, along volar and dorsal aspects of radial border of forearm ; (6) volar and ulnar branches of **medial cutaneous n. of forearm** (int. cutaneous), along volar and dorsal aspects of ulnar border ; (7) **dorsal cutaneous n. of forearm**, along middle of dorsum of forearm ; (8) **superficial branch of radial n.**, after it pierces deep fascia, proximal to wrist at its radial side.

Fascia Antibrachii (Deep Fascia of Forearm).—Invests forearm ; continuous with fascia of arm and strengthened by expansion from tendon of triceps and by lacertus fibrosus (bicipital fascia). Attached to olecranon and dorsal margin of ulna. Sends in septa between muscles. Continuous with fascia of hand, and is thickened at wrist to form two ligaments which hold tendons in position and also assist in binding together the bones to which they are attached :—

(1) **Transverse Carpal Lig.** (Anterior Annular).—Very thick and strong. Bridges across carpal groove, converting it into tunnel. Attached medially to pisiform and hook of os hamatum (unciform). laterally to tuberosity of navicular and volar surface and ridge of multangulum majus (trapezium). A special band of fascia, passing from volar surface of ligament to pisiform superficially, bridges across ulnar vessels and nerve, and is called *volar carpal lig.* (see also p. 147).

(2) **Dorsal Carpal Lig.** (Posterior Annular).—Longer but weaker than transverse carpal lig. and at a more proximal level. Direction oblique from radial to ulnar side and distally. Attached to ridge between volar and lateral surfaces of distal end of radius; to triquetrum (cuneiform) and pisiform; and to dorsal surfaces of distal ends of radius and ulna by 5 septa which divide underlying space into 6 compartments (see also p. 156).

Fascia dorsalis manus is very thin. **Aponeurosis palmaris** (palmar fascia).—Thin over ball of thumb and of little finger. **Central part** is strong and triangular. Connected by *apex* to lig. transversum and palmaris longus. Both *margins* send septa dorsally to join fascia over adductor pollicis and interossei. *Base* divides into 4 slips, which unite with fibrous flexor sheaths of fingers. (See also p. 147.)

Superficial transverse ligament is a band of fibres in the superficial fascia, stretching across volar (palmar) surfaces of roots of fingers, near free edge of webs. On the digits the deep fascia is thickened to form **fibrous flexor or digital sheaths** (see p. 148).

MUSCLES ON VOLAR AND MEDIAL ASPECTS OF FOREARM

(1) SUPERFICIAL MUSCLES

Pronator teres lies obliquely across proximal part of forearm, forming medial boundary of cubital fossa. **Origin**: *humeral head* (il.-tend.), from proximal part of ant. surface of medial epicondyle, distal part of medial epicondylar ridge and intermuscular septum, fascia covering it and septum between it and flex. carpi radialis. *Ulnar head*, from medial margin of coronoid process, by tendinous slip which joins deep surface of muscle. Median nerve passes between the two heads; ulnar artery is posterior to both heads. **Insertion** tend.: rough mark on middle of lateral surface of radius. It is crossed near insertion by radial extensors, brachioradialis, and radial vessels. **Nerve**: C. 6, through median.

It flexes and pronates forearm.

Common Flexor Origin. Flexor carpi radialis, palmaris longus, flex. carpi ulnaris, and flex. digitorum sublimis arise partly or wholly by a common origin consisting of (a) a tendon attached to distal part of anterior surface of medial epicondyle, (b) fascia covering the muscles, and (c) septa between them.

Flexor carpi radialis lies along middle of volar aspect (front) of forearm. **Origin**: common flexor. Its tendon

traverses the groove on multangulum majus (trapezium), piercing attachment of transverse carpal lig. (ant. annular) to that bone, and is inserted into volar surface of base of 2nd metacarpal, and by a small slip into base of 3rd. **Nerve** : C. 6, through median. It flexes and abducts hand ; slightly flexes and pronates forearm.

Palmaris longus lies along ulnar side of flex. carpi radialis. Both tendons are clearly seen, side by side, proximal to wrist. Common flexor **origin**. **Insertion** : by long tendon into volar surface of transverse carpal lig. (ant. annular) and apex of palmar aponeurosis. **Nerve** : C. 6, through median. It flexes wrist, tightens palmar aponeurosis, slightly flexes elbow.

Flexor carpi ulnaris lies along ulnar side of forearm. **Origin** : *humeral head*, common flexor origin. *Ulnar head*, fleshy fibres from medial side of olecranon ; aponeurosis from proximal $\frac{2}{3}$ of dorsal margin of ulna. Ulnar nerve and collateral vessels enter forearm between two heads. **Insertion** by tendon attached to pisiform and continued from there, by lig. pisohamatum and pisometacarpeum, to hook of hamatum (unciform) and base of 5th metacarpal. Ulnar vessels and nerve lie superficially on its radial side, in distal part of forearm. **Nerve** : C. 8, T. 1, through ulnar.

Flexor and adductor of wrist ; slight flexor of elbow.

(2) INTERMEDIATE MUSCLE

Flexor digitorum sublimis lies between superficial and deep muscles. **Origin** : *humeral head* (tend.), from common flexor origin, anterior band of ulnar collateral ligament of elbow, medial margin of coronoid process. *Radial head* (fl.-tend.), from proximal $\frac{2}{3}$ of volar (anterior) margin of radius.

Radial vessels cross radial origin ; ulnar vessels, at first posterior to it, come to lie along its ulnar border, together with ulnar nerve, in distal part of forearm ; median nerve is posterior to it, except near wrist, where it lies between it and flex. carpi radialis. At wrist the tendons for middle and ring fingers lie anterior to the other two, and they all lie behind transverse carpal lig., in front of flexor profundus.

Tendons diverge from one another in the palm. Each enters fibrous flexor sheath of a finger ; is split to transmit tendon of profundus ; and, after reunion, it divides again to be inserted into middle of sides of 2nd phalanx. **Nerve** : C.

6, through median. It flexes 2nd and 1st phalanges and wrist, and the elbow slightly.

(3) DEEP MUSCLES

Flexor digitorum profundus lies on ulna, deep to flex. sublimis and carpi ulnaris. **Origin** (fl.): proximal $\frac{2}{3}$ of volar and medial surfaces of ulna, including medial side of olecranon; adjoining part of interosseous membrane; deep surface of aponeurosis of flexor carpi ulnaris; part arising from aponeurosis and medial side of ulna forms muscular mass felt on medial side of ulna on dorsum of forearm. It forms 4 tendons, each of which enters fibrous flexor sheath, dorsal to a tendon of sublimis, perforates it, and runs on to **insertion** into base of 3rd phalanx. **Nerves**: C. 7, 8, T. 1, through volar interosseous of median, to lateral half; C. 8, T. 1, through ulnar, to medial half. It flexes 3rd, 2nd, 1st phalanges and wrist.

Lumbricales are four small fusiform muscles connected with tendons of flexor profundus in palm (see p. 152).

Flexor pollicis longus lies on radius, dorsal to sublimis. **Origin** (fl.): middle two-fourths of volar surface of radius, and sometimes by a small fleshy slip from medial margin of coronoid process. Its tendon passes through carpal tunnel, enters palm, and turns towards thumb, enters fibrous flexor sheath, and is **inserted** into base of 2nd phalanx of thumb. **Nerve**: C. 7, 8, T. 1, through volar interosseous branch of median.

It flexes 2nd and 1st phalanges, metacarpal, and wrist.

Vaginæ Mucosæ. Three mucous or synovial sheaths enclose flexor tendons at wrist and extend for an inch or more into forearm; one for flex. carpi radialis, another for flex. poll. longus. These two ensheath tendons as far as insertion. The third encloses flexor sublimis and profundus. Its medial part is continued to insertions of little finger tendons. It is prolonged on tendons of three other fingers only as far as middle of palm. Separate sheaths enclose distal parts of these tendons. (See also p. 153.)

Pronator quadratus lies at distal end of forearm, dorsal to flexor tendons and sheaths, median nerve, radial vessels. **Origin** (fl.): distal $\frac{1}{4}$ of volar surface and margin of ulna. **Insertion** (fl.): distal $\frac{1}{4}$ of volar surface of radius and triangular area on ulnar side of radius in front of interosseous

membrane. **Nerve** : C. 7, 8, T. 1, through volar interosseous. It pronates forearm.

Short Muscles of Thumb and Little Finger and Interosseous Muscles. — See Palm of Hand.

MUSCLES ON DORSUM AND LATERAL SIDE OF FOREARM

(1) SUPERFICIAL MUSCLES

Brachio-radialis (supinator longus) lies on radial side of forearm anteriorly and forms lateral boundary of cubital fossa. **Origin** (fl.) : anterior aspect of proximal $\frac{2}{3}$ of lateral epicondylar line of humerus and intermuscular septum. **Insertion** : by tendon into proximal part of lateral surface of distal end of radius, under cover of tendons of abductor longus and extensor brevis pollicis. **Nerve** : C. 5, 6, through radial (musculo-spiral).

It flexes forearm and initiates supination and pronation.

Extensor carpi radialis longus lies on radial border of forearm, dorsal to brachio-radialis. **Origin** (fl.) : anterior aspect of distal $\frac{1}{3}$ of lateral epicondylar line and intermuscular septum. Its tendon is crossed by abductor longus and extensors of thumb ; is enclosed with ext. carp. rad. brevis in mucous sheath under dorsal carpal lig. (post. annular), on dorsum of radius ; and is inserted into base of 2nd metacarpal. **Nerve** : C. 6, 7, through radial (musculo-spiral).

It extends and abducts hand, and slightly flexes elbow.

Common Extensor Origin. — Extensores carpi radialis brevis, digitorum communis, digiti quinti proprius, carpi ulnaris arise partly or wholly by a common origin, consisting of (a) a tendon attached to distal part of anterior surface of lateral epicondyle, (b) fascia covering and between muscles.

Extensor carpi radialis brevis lies on radial side and dorsum of forearm. **Origin** : common extensor origin and radial collateral ligament of elbow. Its tendon runs along ulnar side of longus and is inserted into base of 3rd metacarpal, and usually also into 2nd. **Nerve** : C. 6, 7, through deep branch of radial (post. interosseous of musculo-spiral).

It extends and slightly abducts hand.

Extensor digitorum communis lies on dorsal surface of forearm, towards radial side. Common extensor origin.

Its tendon is enclosed with *ext. indicis proprius* in mucous sheath in a compartment of dorsal carpal ligament on dorsum of radius, and divides into tendons which diverge to fingers. On dorsal surface of 1st phalanx each tendon expands to form *dorsal extensor expansion*, which is **inserted** into bases of 2nd and 3rd phalanges. **Nerve** : C. 6, 7, 8, through dorsal interosseous. It extends phalanges and hand.

Extensor digiti quinti proprius (*ext. minimi digiti*) lies along middle of dorsum of forearm. Common extensor **origin**. Its tendon is ensheathed in a compartment of dorsal carpal ligament between radius and ulna, and is **inserted**, in common with tendon from *ext. communis* to little finger. **Nerve and action** : same as preceding muscle.

Extensor carpi ulnaris lies along radial side of dorsal margin of ulna. **Origin** : common extensor origin, and dorsal margin of ulna, through aponeurosis of flexor carpi ulnaris. Its tendon is enclosed in mucous sheath in most medial compartment of dorsal carpal ligament, and is **inserted** into base of 5th metacarpal. **Nerve** : C. 6, 7, 8, through dorsal interosseous. It extends and adducts hand.

Anconæus. Small and triangular. Lies on radial side of dorsal aspect of elbow. **Origin** (*tend.*) : distal part of dorsal surface of lateral epicondyle ; posterior ligament of elbow. **Insertion** (*fl.*) : triangular area on proximal $\frac{1}{4}$ of dorsal surface of ulna and lateral surface of olecranon, fascia covering it. **Nerve** : C. 7, 8, through radial (musculo-spiral). It extends forearm.

(2) DEEP MUSCLES

Supinator surrounds proximal $\frac{1}{2}$ of radius, and forms part of floor of cubital fossa. **Origin** (*fl.-tend.*) : (1) supinator crest of ulna and hollow in front of it, distal to radial notch ; (2) annular (orbicular) and radial collateral ligaments ; (3) lateral epicondyle ; (4) fascia covering it. Fibres curve round behind radius and are **inserted** into dorsal, lateral and volar aspects of its proximal third. **Nerve** : C. 6, through deep branch of radial (post. interosseous of musculo spiral), which, after supplying it, traverses it and divides it into two laminae.

Abductor pollicis longus (*ext. ossis metacarpi pollicis*) lies *deeply* in middle third of forearm, *superficially* on dorsum and radial side of distal third. **Origin** (*fl.*) : most proximal of the three narrow impressions on lateral half of

dorsal surface of ulna ; middle $\frac{1}{3}$ of dorsal surface of radius ; interosseous membrane. It crosses extensores carpi radiales. Its tendon is enclosed in mucous sheath with ext. poll. brevis, in most lateral compartment of dorsal carpal ligament (post. annular), upon insertion of brachio-radialis ; it crosses radial artery and is inserted into base of 1st metacarpal. **Nerve** : C. 6, through dorsal interosseous. It draws metacarpal of thumb away from palm ; extends and abducts hand.

Extensor pollicis brevis (ext. primi internodii pollicis) lies on dorsal and lateral surfaces of distal $\frac{1}{3}$ of forearm. **Origin** (fl.) : proximal part of distal $\frac{1}{3}$ of dorsal surface of radius and interosseous membrane. It lies along ulnar side of abductor, and its tendon proceeds over metacarpal to be inserted into dorsum of base of 1st phalanx of thumb. **Nerve** : C. 6, 7, 8, through dorsal interosseous. It extends 1st phalanx, extends and abducts hand.

Extensor pollicis longus (ext. secundi internodii pollicis) lies deeply in dorsum of forearm, superficially on dorsum of wrist and thumb. **Origin** (fl.) : about middle $\frac{1}{3}$ of dorsum of ulna from the middle one of the three impressions on lateral half ; interosseous membrane. Its tendon lies enclosed in mucous sheath on dorsal surface of distal end of radius, in a compartment of dorsal carpal ligament ; and proceeds to insertion into base of 2nd phalanx. **Nerve** : same as brevis. It extends phalanges and metacarpal of thumb ; extends and abducts hand.

Extensor indicis proprius lies deeply in distal $\frac{1}{3}$ of forearm, superficially on dorsum of wrist and hand. **Origin** (fl.) : proximal part of distal $\frac{1}{3}$ of dorsal surface of ulna—most distal of the three impressions—and from interosseous membrane. Tendon joins the tendon from ext. communis to index at the finger. **Nerve** : same as preceding.

It extends index and hand.

Vaginæ Mucosæ.—Mucous or synovial sheaths surround extensor tendons and line compartments of dorsal carpal lig. (post. annular). Mucous or synovial sheaths of tendons around wrist and ankle begin one inch proximal to respective “annular” ligaments : in the case of those inserted into carpus, metacarpus, tarsus, metatarsus, they extend to the insertion, except in case of peroneus longus ; in the case of those inserted into phalanges they extend to middle of hand or foot, excepting flexor pollicis longus, and flexors of little finger.

Fossa cubitalis (antecubital fossa) is a triangular hollow on anterior aspect of elbow. **Base** : imaginary line between epicondyles. **Lateral boundary** : brachio-radialis. **Medial boundary** : pronator teres. **Apex** : where these muscles cross. **Roof** : (1) skin ; (2) superficial fascia containing median basilic and median cephalic veins, lateral cutaneous and volar branch of medial cutaneous nerves of forearm (cutaneous branch of musculo-cutaneous and ant. branch of int. cutaneous) ; (3) deep fascia, which includes lacertus fibrosus (bicipital fascia), and is pierced by profunda vein. **Floor** : brachialis proximally and medially, supinator (brevis) distally and laterally.

Contents : brachial, radial and ulnar arteries and their venae comites ; median nerve ; tendon of biceps ; fat. *Tendon of biceps* lies laterally, and leaves the space by passing dorsally between muscles of floor. *Median nerve* lies medially, and leaves between heads of pronator teres. *Brachial artery* lies between tendon and nerve, and ends opposite neck of radius by dividing into radial and ulnar. *Ulnar artery* passes under cover of pronator teres. *Radial artery* runs to apex to be overlapped by brachio-radialis.

When boundaries are pulled apart, other structures, not properly within the fossa, come into view. *Radial nerve* (musculo-spiral) is seen deeply, between brachialis and ext. carpi radialis longus, dividing, just proximal to elbow-joint, into its superficial (O.T. radial) and deep (O.T. post. interosseous) branches, which descend on capsule of joint, anterior to capitulum of humerus. The *superficial branch* passes distally under cover of brachio-radialis ; the *deep branch* supplies ext. carpi radialis brevis and supinator (brevis), and then sinks into supinator. *Recurrent branch of radial artery* ascends upon supinator, between the branches of radial nerve, to anastomose with anterior branch of profunda, which accompanies radial (musculo-spiral) nerve. (On ulnar side, the *volar* (anterior) *ulnar recurrent artery* ascends upon brachialis, under cover of pronator teres, to anastomose with anterior branch of inferior ulnar collateral (anastomotica).

WRIST, HAND AND DIGITS

Surface Anatomy —**Thenar eminence** is the ball of the thumb, and is produced by three of the short muscles of the thumb. **Hypothenar eminence** is the ball of the little finger and is produced by its three short muscles. Between and distal to the eminences is the **hollow of the palm**. The knob at proximal end of hypothenar eminence is the **pisiform** ; the tendon descending to it is the **flexor carpi ulnaris**. **Hook of os hamatum** (unciform) can be felt, by deep pressure, distal to pisiform, and more to the radial side. Two tendons descending about middle of wrist are **flexor carpi radialis** and **palmaris longus** : palmaris is the medial of the two and may be absent. The tendon which can be felt and may rise into view on the ulnar side of palmaris, when fingers and wrist are

flexed, is the **tendon of flexor sublimis to ring finger**; **ulnar vessels and nerve** lie between it and **flex. carpi ulnaris**. **Tubercle of navicular** is felt proximal to thenar eminence, in the angle between it and **flex. carpi radialis**. A line, concave towards forearm, drawn between pisiform and tubercle of navicular, indicates position of proximal margin of **transverse carpal lig.** (ant. annular). **Ridge on multangulum majus** (trapezium) is felt immediately distal to the tubercle, and the two may form one prominence, seen and felt best when hand is dorsi-flexed. **Ridge on radial border of wrist**, proximal to ball of thumb, is produced by tendons of **abductor pollicis longus** (ext. ossis metacarpi poll.) and **ext. poll. brevis**. When thumb is abducted and extended a hollow is produced on radial side of wrist, bounded in front by abductor and ext. brevis of thumb, behind by ext. longus of thumb and ext. carpi rad. longus. Navicular and multangulum majus (trapezium) form its floor. Radial artery crosses it. Branches of superficial branch of radial nerve can be felt crossing the tendons. **Radial artery** is felt beating on distal end of radius; its **superficial volar branch** runs across wrist-joint towards ulnar side of ball of thumb, and may be large enough to be seen beating. **Line of metacarpo-phalangeal joints** is nearly opposite most distal crease on palm, about $\frac{1}{2}$ inch proximal to the crease at bases of fingers; distal to these joints, the **web of fingers** is formed by the skin between the phalanges. **First interphalangeal joint** is opposite the more proximal of the 2 or 3 creases near middle of each finger. **Second interphalangeal joint** is just beyond the creases near end of finger. On the dorsum, the joints in each case are just beyond the **knuckles**, which are formed by the heads or distal ends of the metacarpals and of first and second rows of phalanges. When hand is flexed, the **bases of metacarpals** can be seen and felt through extensor tendons, as a number of small irregular prominences.

Volar or Palmar Aspect of Wrist, Hand and Digits

Superficial fascia is thin and dense over centre of palm, and fat is divided into fine lobules by septa connecting skin to palmar aponeurosis. It is more fatty and less fibrous near margins of palm and on digits, and at the free extremities of the digits it is thickened to form the pulp of the finger tips. On the digits it contains digital vessels and nerves. In the palm it contains small unnamed cutaneous vessels, cutaneous nerves, palmaris brevis and the superficial transverse ligament:—

Terminal twigs of musculo-cutaneous nerve and of **superficial branch of radial nerve** (O. T. radial branch of musculo-spiral) supply skin over proximal and radial parts of thenar eminence, respectively. **Palmar cutaneous branch of median nerve** arises

near wrist, appears between flex. carpi rad. and palmaris longus, pierces deep fascia just proximal to wrist, crosses superficial to transverse carpal lig. (ant. annular), supplies skin on lateral and median parts of palm. **Palmar cutaneous branch of ulnar nerve** arises in distal $\frac{1}{3}$ of forearm, descends on ulnar artery; pierces deep fascia on radial side of flex. carpi ulnaris near its insertion; crosses transverse carpal lig., and supplies skin on medial part of palm.

Palmaris brevis arises from ant. surface of transverse carpal lig., and ulnar margin of central part of palmar aponeurosis (fascia); passes medially, superficial to ulnar vessels and nerve, to be *inserted* into skin on ulnar border of hand. Superficial branch of *ulnar nerve* supplies it. It wrinkles skin on ulnar border of hand.

Superficial transverse ligament lies across the roots of the fingers and in the web, near its free edge; may be seen in the living hand if the fingers are abducted from one another and slightly flexed.

Deep fascia in palm is called palmar aponeurosis. It is thin over thenar and hypothenar eminences, while central part, in hollow of hand, is thickened. Deep fascia is greatly thickened opposite wrist bones, and is called transverse carpal ligament. It is thickened over fingers to form fibrous digital or flexor sheaths.

Transverse carpal ligament (anterior annular lig.) is very thick and strong, and measures about an inch proximo-distally and from side to side. It bridges across concavity of carpus, converting it into a canal through which flexor tendons of fingers and thumb, with their sheaths, and the median nerve pass into palm. It is continuous *proximally* with fascia of forearm, *distally* with palmar aponeurosis. It is attached, *on the ulnar side*, to pisiform and hook of os hamatum (unciform); *on radial side*, to tubercle of navicular (scaphoid) and palmar surface and ridge of multangulum majus (trapezium).

It gives partial insertion to flexor carpi ulnaris and palmaris longus, and origin to abductor brevis, flexor brevis and opponens pollicis; to flexor brevis and opponens digiti quinti; and to palmaris brevis; these occupy most of its volar or palmar surface and distal border.

The *palmar surface* is, further, in relation to: (1) palmaris longus tendon, descending to insertion into the ligament and into apex of palmar aponeurosis; (2) palmar cutaneous branch of median, descending on radial side of tendon; (3) palmar cutaneous branch of ulnar, on ulnar side of tendon; (4) ulnar vessels and nerve, on radial side of pisiform; (5) a band of fascia, called *volar carpal lig.*, attached to palmar surface of transverse lig. and to pisiform, bridging across ulnar vessels and nerve. Tendon of flex. carpi radialis, with its mucons or synovial sheath, traverses groove on palmar surface of multangulum majus (trapezium), between the attachments of the transverse carpal ligament to that bone.

Central part of palmar aponeurosis (palmar fascia) protects vessels, nerves and tendons which lie deep to it. It is triangular in shape. **Apex** is attached to transverse carpal lig. and receives part

of insertion of palmaris longus. **Base** divides, opposite heads of metacarpals, into 4 slips. These are connected by *transverse fibres*, and between the slips the digital vessels and nerves and the lumbricals are seen. A few superficial fibres of each slip run on to be attached to skin at creases of the finger. Remainder divides into two parts, which diverge and pass dorsally to be attached to transverse metacarpal ligament. These two diverging parts form an arch beneath which the flexor tendons pass into the fibrous flexor sheath, and their distal edges are continuous with the proximal end of fibrous flexor sheath. The **margins** of the aponeurosis are connected with the fascia over thenar and hypothenar eminences, and they send septa dorsally to be connected with the fascia covering adductor pollicis, the interossei and deep volar arch (deep palmar arterial arch). These septa divide the palm into three compartments: a lateral, occupied by muscles of the thumb; a medial, occupied by hypothenar muscles; an intermediate, occupied by superficial volar arch and its branches, branches of median nerve, tendons of flexor sublimis and profundus, their sheaths and the lumbricals.

Fibrous flexor sheaths are attached to the margins of 1st and 2nd phalanges of each finger, and 1st phalanx of thumb, and to the margins of volar accessory ligaments of the joints of each finger. Together with phalanges and ligaments, each forms a tunnel occupied by flexor tendons and their mucons or synovial sheaths. Each is firm and dense opposite phalanges, but weak opposite joints, in order that movements may not be impeded. Unnecessary names have been devised for these different parts: *vaginal digital ligaments* for strong parts; *annular ligaments* for weak parts; and *cruciate ligaments* for some intercrossing fibres sometimes found between weak and strong parts.

The volar accessory and transverse metacarpal ligaments, mentioned above, are connected with the joints. **Volar accessory lig.** is a dense fibro-cartilaginous plate, attached firmly to the volar surface base of 1st phalanx, loosely to metacarpal, proximal to its head. Its *dorsal surface* is in contact with head of metacarpal, and forms part of its socket; its *volar* or *palmar surface* is grooved by the passage of flexor tendons; its *margins* are connected with the fibrous flexor sheaths and the slips of palmar aponeurosis, with the collateral lig. of the joint and with the transverse metacarpal lig. Interphalangeal joints have similar volar accessory ligaments.

Transverse metacarpal ligament consists of 3 flat bands connecting the margins of the volar accessory ligaments of the metacarpophalangeal joints of the 4 fingers. Digital vessels and nerves and lumbrical muscles lie on their *palmar surfaces*, interosseous muscles on their *dorsal surfaces*.

Short Muscles of Thumb.—There are two groups of these: (A) the abductor pollicis brevis, flexor pollicis brevis, opponens pollicis, which form the thenar eminence and lie on radial side of flexor pollicis

longus tendon. Lateral division of *median nerve* supplies them by fibres derived ultimately from 6th and 7th cervical nerves (possibly C. 8, T. 1). (B) Adductor pollicis and interosseus primus volaris, which lie on ulnar side of flex. poll. longus tendon. *Deep branch of ulnar* supplies them by fibres derived from C. 8, T. 1.

Abductor pollicis brevis is subcutaneous, on radial part of thenar eminence. It **arises** by fleshy fibres from tubercle of navicular, ridge on multangulum majus (trapezium), transverse carpal lig. ; and is **inserted** by tendon into radial side of base of 1st phalanx of thumb. It abducts at carpo-metacarpal joint, and slightly flexes 1st phalanx.

Flexor pollicis brevis is subcutaneous, on ulnar part of thenar eminence. It **arises** by fleshy and tendinous fibres from distal border of transverse carpal lig. (ant. annular), and often from ridge on multangulum majus (trapezium) ; and is **inserted** by tendon into 1st phalanx, in company with abductor. It flexes 1st phalanx and metacarpal.

Opponens pollicis is under cover of the preceding two. It **arises** by fleshy and tendinous fibres from transverse carpal lig. and ridge on multangulum majus, and is **inserted** by fleshy and tendinous fibres into radial border and radial half of palmar surface of metacarpal of thumb. It flexes metacarpal and rotates it medially.

Adductor pollicis lies deeply in radial half of palm, and has two fleshy heads, between which radial art. enters palm. (a) **Oblique head arises** from palmar surfaces of multangulum majus and minus (trapezium and trapezoid), capitatum (os magnum), bases of 2nd, 3rd, 4th metacarpals, ligaments connecting these bones, and fibrous sheath of flex. carpi radialis tendon. (b) **Transverse head arises** from palmar surface of shaft of 3rd metacarpal, and fascia covering interossei in 2nd and 3rd spaces. The heads join each other and are **inserted** by tendon into ulnar side of base of 1st phalanx of thumb, and often by a separate slip, which crosses dorsal to tendon of flex. pollicis longus, to radial side of base of 1st phalanx. They draw thumb and its metacarpal towards palm.

Sesamoid bones are developed in tendons of insertion of adductor and flexor brevis. They replace the volar accessory ligament of metacarpo-phalangeal joint of thumb, and articulate with palmar surface of head of metacarpal.

Interosseus primus volaris, called also *deep head of flexor brevis*, is in series with palmar interossei ; is very slender, and lies between adductor and 1st dorsal interosseous ; *arises* from ulnar side of base of metacarpal of thumb, and is *inserted* into ulnar side of base of 1st phalanx.

Short muscles of little finger are the abductor, flexor brevis and opponens, and they form the hypothenar eminence. *Deep branch of ulnar nerve* supplies them by fibres derived from C. 8, T. 1.

Abductor digiti quinti lies superficially in ulnar part of hypothenar. It **arises** by fleshy fibres from pisiform, tendon of flexor

carpi ulnaris, lig. piso-hamatum (pisi-unciform) and piso-metacarpum ; and is **inserted** by tendon into ulnar side of base of 1st phalanx of little finger, which it abducts and slightly flexes.

Flexor digiti quinti brevis lies superficially in radial part of hypothenar, and may be fused with abductor or opponens. It **arises** by fleshy and tendinous fibres from transverse carpal lig. and hook of hamatum (unciform), and is **inserted** in common with abductor.

Opponens digiti quinti is placed under cover of preceding two. It **arises** by fleshy and tendinous fibres from transverse carpal lig. and hook of os hamatum, and is **inserted** by fleshy fibres into ulnar border and ulnar half of palmar surface of 5th metacarpal, which it draws forwards and turns towards radial side.

Ulnar artery leaves the anterior surface of flexor profundus at wrist ; passes on to superficial aspect of transverse carpal lig. (ant. annular), where it lies either deep or superficial to the volar carpal lig., on radial side of ulnar nerve and pisiform ; leaves the transverse lig., and descends upon lig. piso-hamatum (pisi-unciform lig.) to reach ulnar side of hook of os hamatum (unciform), under cover of palmaris brevis, where it divides into superficial and deep branches. **Superficial branch** becomes the superficial volar arch. **Deep branch**, in company with deep branch of ulnar nerve, passes dorsally and distally between abductor digiti quinti and flexor brevis, then laterally under cover of flexor brevis and opponens, or between the two, or through opponens, and joins ulnar end of deep volar arch.

Before leaving profundus the ulnar artery gives off (1) the **volar ulnar carpal artery**, which winds round ulnar side of profundus, and runs laterally to join volar radial carpal on volar surface of distal end of radius ; and (2) **dorsal ulnar carpal artery**, which passes dorsally under cover of flexor carpi ulnaris, then distally on ulnar side of wrist-joint, and, lastly, laterally under cover of extensor carpi ulnaris to join dorsal radial carpal on distal row of carpus.

Superficial volar arch is formed by superficial branch of ulnar artery, and is completed on radial side by superficial volar branch of radial, or princeps pollicis, or radialis indicis. It is accompanied by *venæ comites*. **Superficial to it** are palmaris brevis, palmar aponeurosis, palmar cutaneous branches of median and ulnar nerves. **Deep to it** are flexor brevis and opponens dig. quinti ; digital branches of median nerve, tendons of flexor digitorum sublimis and profundus, and the lumbricals.

Course of terminal part of ulnar artery and the superficial arch may be mapped out by a line drawn from radial side of pisiform towards ring finger as far as level of distal border of outstretched thumb, then turned laterally, and finally a little proximally, to end at distal or ulnar margin of thenar eminence, in line with radial side of middle finger.

Branches of Superficial Volar Arch.—(1) Small branches to skin and neighbouring muscles. (2) **Four common volar digital**

arteries, of which the first runs upon flex. dig. quinti brevis to ulnar side of little finger. The other three lie in the intervals between long flexor tendons, upon the digital nerves and lumbrical muscles, deep to palmar aponeurosis. Near web of fingers, each is joined by volar metacarpal branch (palmar interosseous) from deep arch, and by distal perforating branch from dorsal metacarpal (dorsal interosseous), and then divides into two *proper volar digital arteries*, which supply contiguous sides of the fingers.

Near roots of fingers the arteries cross the nerves and lie dorsal to them on the sides of the fingers; they supply the tissues on sides and palmar aspects of fingers, and dorsum on 2nd and 3rd phalanges. They anastomose with small dorsal digital branches of dorsal metacarpal arteries, and assist them to supply dorsum of 1st phalanx; and terminal branches of the two volar digital arteries on each finger form arches and plexuses in bed of nail and pulp of finger.

Median nerve leaves forearm and passes deep to transverse carpal lig. (ant. annular), on radial side of sublimis tendons, and overlapped by the synovial sheath; turns on to palmar surface of tendons and divides into lateral and medial divisions, which emerge into palm and send branches distally, deep to superficial volar arch.

Lateral division gives a branch to supply the three muscles of thenar eminence, and then divides into 3 *digital nerves*. Two of the digital nerves run along ulnar border of flex. poll. brevis and flex. poll. longus tendon, anterior to adductor, separate to pass along opposite sides of thumb. The other digital branch passes distally upon 1st lumbrical, which it supplies, and runs along radial side of index.

Medial division divides into 2 *digital nerves*, which descend upon 2nd and 3rd lumbricals, supplying 2nd always and 3rd sometimes. They each split into two and supply contiguous sides of index, middle and ring fingers.

Digital branches of median supply sides and palmar aspect of thumb, index and middle fingers, and radial half of ring finger, and also the dorsum on 2nd phalanx of thumb, 2nd and 3rd phalanges of the other 2½ digits. Digital arteries are superficial to them in palm, dorsal to them on fingers. Small oval bodies, called *Pacinian corpuscles*, are connected with terminal twigs of nerves in digits.

The median nerve corresponds to medial plantar nerve of foot.

Ulnar nerve lies on ulnar side of ulnar art., upon transverse carpal lig. (ant. annular), lig. pisio-hamatum (pisiformiform) and ulnar side of hook of hamatum, successively, under cover of volar carpal lig. and palmaris brevis, and divides into superficial and deep branches (former may be rolled by the finger on hook of hamatum).

Superficial branch supplies palmaris brevis, passes from beneath it and divides into two *digital branches*, of which one accompanies digital branch of superficial arch over flexor brevis, and runs along ulnar side of little finger; and the other accompanies digital artery over 4th lumbrical; communicates with adjoining

digital branch of median ; divides into two branches which run along contiguous sides of ring and little fingers. As in the case of median, they supply palmar surfaces and sides along whole length, and dorsal surfaces over 2nd and 3rd phalanges ; Pacinian corpuscles are connected with their terminal twigs ; digital arteries are superficial to them in palm, dorsal to them on sides of fingers.

Deep branch runs with deep branch of artery, dorsally between abductor and flexor brevis, laterally under cover of flexor brevis and opponens, supplying all three ; then laterally across palm, deep to long flexor tendons and lumbricals, upon proximal ends of interossei and metacarpals near their bases, on concave or proximal side of deep volar arch. Sends 3 branches distally to supply interossei in spaces between metacarpals of fingers, and the 3rd and 4th lumbricals ; breaks up finally to supply adductor pollicis, 1st dorsal interosseous and interosseus primus volaris : *i.e.* 14 muscles in all.

Ulnar nerve corresponds to lateral plantar nerve of foot.

Tendons of flexor digitorum sublimis lie between transverse carpal lig. (ant. annular) and flexor profundus at wrist ; and those for middle and ring fingers are superficial to those for index and little fingers. Fibres from radius help to form tendons to middle and ring fingers, but not the other two. In the palm each tendon runs towards its finger, deep to palmar aponeurosis and superficial arch, superficial to corresponding profundus tendon ; and both tendons enter fibrous flexor sheath opposite head of metacarpal. Opposite 1st phalanx each sublimis tendon splits to allow profundus tendon to pass through it. Opposite base of 2nd phalanx the two halves reunite by their dorsal margins and form a gutter in which profundus tendon lies ; then, after partial decussation, they separate again to be inserted into margins of 2nd phalanx about its middle.

Flexor Digitorum Profundus.—At wrist, lies between flex. sublimis and carpus, on medial side of flexor pollicis longus. Tendon for index becomes separate some distance proximal to wrist, and the part of fleshy belly from which it springs is separable for some distance ; this is associated with the more frequent independent use of index. Tendons for other three fingers are combined in one flat mass, but separate as they enter palm. Tendons give origin to lumbricals in palm, and run to fingers, deep to sublimis tendons, superficial to deep volar arch, adductor pollicis, interossei and metacarpals. Near metacarpo-phalangeal joint each enters fibrous flexor sheath, passes through corresponding sublimis tendon opposite 1st phalanx, and runs on to **insertion** into volar (palmar) surface of base of 3rd phalanx. It flexes 3rd, 2nd, 1st phalanges and wrist.

Lumbrical muscles are four small fusiform muscles, which arise from tendons of flexor profundus ; pass distally between the tendons, deep to digital vessels and nerves ; cross the volar surface of transverse metacarpal lig. ; end in tendons which pass obliquely dorsally on radial sides of metacarpo-phalangeal joints, to be **inserted** mainly

into radial sides of extensor tendons, partly into base of phalanx and capsule of joint. Each flexes the 1st phalanx and extends the other two, since it passes from palmar to dorsal aspect over metacarpophalangeal joint and is inserted into extensor tendon.

First arises from radial side of tendon to index ; **second** from radial side of tendon to middle finger ; *median nerve* supplies them on their volar aspects by fibres derived from C. 6 (7) (possibly C. 8, T. 1), digital branch to radial side of index giving the branch to 1st, digital branch to next cleft giving branch to 2nd. **Third** arises from contiguous sides of tendons to middle and ring fingers ; **fourth** from contiguous sides of tendons to ring and little fingers ; *deep branch of ulnar* supplies them on dorsal aspects by fibres derived from C. 8 (T. 1) ; third is sometimes supplied also by digital branch of median to cleft between middle and ring fingers.

Flexor pollicis longus tendon crosses from lateral to medial side of flexor carpi radialis, between it and wrist-joint ; enters carpal tunnel ; runs distally, on radial side of flexor profundus ; enters palm and turns towards thumb, crossing sheath of flexor carpi radialis superficially ; runs between flexor pollicis brevis and adductor, enters fibrous flexor sheath, and is inserted into volar surface of base of 2nd phalanx of thumb.

Mucous or Synovial Sheaths Tendon of flexor poll. longus is enveloped in a separate mucous sheath, which extends into forearm for an inch, and distally as far as insertion. Tendons of flexor sublimis and profundus are enclosed in a common sheath, which extends into forearm for an inch, ensheathes tendons of little finger to insertion, and tendons of other fingers and the lumbricals as far as middle of palm. Proximal to heads of metacarpals these tendons acquire new sheaths, which surround them on the fingers. Within the fibrous flexor sheath of each digit near the insertion of a tendon, the mucous sheath is pinched up to form a triangular fold, seen between tendon and phalanx when they are pulled apart. These folds are called **vincula brevia**. At more proximal levels slender fibrous cords, with mucous covering, pass between tendons and phalanges. These are called **vincula longa**. Blood-vessels run in the vincula to the tendons.

Mucous sheaths are closed sacs, each consisting of two layers continuous with one another, one enclosing the tendon or tendons, the other lining the space in which it lies. On the digits the sheath lines the fibro-osseous canal and covers the tendons, and the two parts are continuous at proximal and distal ends, but the connection between that on the tendons and that on the phalanges is represented only by the vincula, though in a few instances these form broad sheets like mesenteries. The common sheath of the flexors of the fingers is complicated by the number of tendons. At the wrist it lines the greater part of carpal tunnel, and at radial side passes from carpus and transverse lig. on to tendons, covering them and dipping in amongst

them, and at ulnar side it is tucked in for a variable distance between the sublimis and profundus groups.

Radial artery, at wrist, leaves distal end of radius and, accompanied by *venæ comites*, runs distally and dorsally to proximal end of 1st inter-metacarpal space, where it dips between the heads of 1st dorsal interosseous muscle, turns medially, enters palm between heads of adductor pollicis and becomes deep volar arch.

It lies on distal end of radius, superficially; then upon radial collateral lig. of wrist, under cover of abductor pollicis longus and ext. poll. brevis; then upon navicular and multangulum majus, where it may again be felt pulsating, in the hollow on radial side of wrist; then upon base of 1st metacarpal; and it is crossed, before it disappears, by ext. poll. longus, and superficial branches of radial nerve; and before it appears in palm the ulnar head of 1st dorsal interosseous, 1st palmar interosseous and 2nd metacarpal are dorsal to it, and adductor pollicis is superficial.

Branches of Radial Artery.—Volar radial carpal, superficial volar, given off at distal end of radius; dorsales pollicis, dorsalis indicis, dorsal radial carpal, given off on wrist; princeps pollicis, radialis indicis, given off between 1st dorsal interosseous and adductor; (besides radial recurrent, given off at elbow, and unnamed muscular branches given off during its course through forearm).

Volar radial carpal artery runs medially on distal end of radius, under cover of flexor tendons, and joins similar branch of ulnar to form volar carpal arch. **Superficial volar artery** runs across wrist-joint and over or through thenar muscles near their origins, supplying them, and often ends by completing superficial volar arch.

Dorsales pollicis arteries run along 1st metacarpal to opposite sides of thumb. **Dorsalis indicis artery** runs distally upon 1st dorsal interosseous and along radial side of dorsum of forefinger. **Dorsal radial carpal artery** runs medially upon distal row of carpus deep to extensor tendons and joins similar branch of ulnar to form dorsal carpal arch, from which *dorsal metacarpal arteries* (dorsal interosseous) run distally upon interosseous muscles in 2nd, 3rd, 4th inter-metacarpal spaces, and end in small dorsal digital arteries for dorsum of 1st phalanges. At proximal ends of metacarpal spaces they are joined by proximal perforating arteries, which have come through the spaces from deep volar arch; and near distal ends they send *distal perforating arteries* to join common volar digital arteries.

Princeps pollicis artery runs laterally and distally, dorsal to oblique part of adductor pollicis and to flex. poll. longus; appears between adductor and flexor brevis; divides into two branches which run distally, one on each side of flexor longus pollicis. **Radialis indicis artery** runs distally between transverse head of adductor and 1st dorsal interosseous, and along radial side of index with digital nerve.

Deep volar arch (deep palmar arch), the continuation of radial artery, extends from interval between transverse and oblique heads of

adductor pollicis, across 3rd and 4th metacarpals, just distal to their bases, to reach base of 5th, where it is joined by deep branch of ulnar. Its level is $\frac{1}{2}$ inch more proximal than superficial arch. Dorsal to it are metacarpals and interossei, while flexor tendons, their mucous sheath, lumbricals and digital branches of median nerve separate it from superficial arch.

Branches.—Recurrent, proximal perforating, volar metacarpal (palmar interosseous).

Recurrent branches run proximally upon volar (palmar) aspect of carpus and wrist-joint, and anastomose with volar carpal arch. **Perforating branches** pass dorsally through proximal parts of spaces between metacarpals of fingers, each between heads of corresponding dorsal interosseous muscle, and join dorsal metacarpal arteries (dorsal interosseous). Three **volar metacarpal branches** run distally, upon interosseous muscles of medial three spaces, and join digital branches of superficial arch, just before their bifurcation.

Interosseous muscles are 7 in number, 3 volar and 4 dorsal. They are the deepest structures in palm, and their tendons of insertion pass dorsal to transverse metacarpal lig. Each one is inserted into extensor tendon, base of 1st phalanx, and capsule of metacarpo-phalangeal joint of finger upon which it acts (cf. lumbricals). *Deep branch of ulnar nerve* supplies them all, by fibres derived from C. 8, T. 1. The dorsal interossei lie in inter-metacarpal spaces and are seen, therefore, on dorsum of hand as well as in palm.

Volar interossei act on index, ring and little fingers. Each *arises* by fleshy fibres from palmar surface of metacarpal of finger upon which it acts. **First** is *inserted* into ulnar side of index; **second**, into radial side of annularis; **third**, into radial side of minimus. They adduct these fingers towards middle finger, and, besides, each flexes the metacarpo-phalangeal joint and extends interphalangeal joints (cf. lumbricals).

Each **dorsal interosseous** *arises* by two fleshy heads from adjacent sides of metacarpals between which it lies. **First** is *inserted* into radial side of index; **second**, into radial side of medius; **third**, into ulnar side of medius; **fourth**, into ulnar side of annularis. Like the volar interossei, each flexes 1st phalanx and extends 2nd and 3rd. First and fourth abduct index and annularis from median, while second and third alternately abduct and adduct medius, *i.e.* second abducts towards index, third adducts it to its former position, and, continuing to act, abducts it towards annularis, when second restores it to position.

Each finger, therefore, is provided with an adductor and an abductor. Index, medius and annularis have each two interossei, while minimus has its abductor digiti quinti, and has the 3rd volar interosseous as adductor.

First dorsal interosseous forms the fleshy mass seen on dorsal aspect, between metacarpals of thumb and index, and its action can

be studied readily on the living hand. Radial artery passes between its two heads ; perforating arteries pass between heads of others.

Flexor carpi radialis tendon, as it lies proximal to wrist, has the radial artery a little to its radial side, median nerve close to ulnar side, on a deeper plane. It crosses superficial to flex. poll. longus opposite wrist-joint, descends upon volar surface of tubercle of navicular, traverses tunnel formed by attachment of transverse carpal lig. (ant. annular) to both sides of groove on multangulum majus (trapezium); and it is **inserted** into volar surface of base of metacarpal of index, sending a small slip to base of 3rd. A prolongation of transverse lig. over it to its insertion is called its fibrous sheath.

Dorsal Aspect of Wrist, Hand and Digits

On the dorsal aspect the **superficial fascia** is thin and contains superficial veins, lymph vessels and nerves. Veins form plexuses in which arches are seen on dorsum of 1st phalanges, and on dorsum of hand near heads of metacarpals; and they drain into cephalic and basilic veins.

Terminal branches of **superficial branch of radial nerve** (radial branch of musculo-spiral) diverge at lateral side of distal end of radius to be distributed to radial $\frac{2}{3}$ of dorsum of hand, proximal parts of dorsal surfaces of thumb, index, middle and half the ring finger. **Dorsal branch of ulnar nerve** arises in middle $\frac{1}{3}$ of forearm; passes dorsally under cover of flex. carpi ulnaris; is joined by dorsal ulnar carpal artery; pierces deep fascia and runs distally upon distal end of ulna, and ulnar side of wrist-joint between flexor and ext. carpi ulnaris; and gives branches to ulnar part of dorsum of hand, proximal part of little finger, ring finger and part of middle finger, overlapping the distribution of superficial branch of radial.

Deep fascia is thin, but immediately proximal to wrist is thickened to form **dorsal carpal ligament** (posterior annular), which is longer but weaker than transverse carpal lig. (ant. annular), and at a more proximal level. It stretches obliquely from ridge between volar and lateral surfaces of distal end of radius to os triquetrum (cuneiform) and pisiform; and five septa, attached to distal ends of radius and ulna, divide the space under it into 6 compartments occupied by extensor tendons and their mucous sheaths. They are arranged as follows:—On lateral surface of radius, (*a*) abductor pollicis longus, ext. poll. brevis. On dorsal surface of radius, (*b*) extensor carpi rad. longus and brevis; (*c*) ext. poll. longus; (*d*) ext. dig. communis, ext. indicis proprius. Between radius and ulna, (*e*) ext. dig. quinti proprius. On dorsal surface of ulna, (*f*) ext. carpi ulnaris.

Tendons are enclosed in mucous sheaths, beginning about an inch proximal to ligament, and extending to insertion of those inserted into metacarpals, and to middle of hand in the case of those inserted into phalanges.

Ext. carpi radialis longus is supplied, in arm, by *radial nerve* (musculo-spiral); all the others, in forearm: ext. carpi rad. brevis by its *deep branch*; the remaining muscles by dorsal interosseous.

Abductor pollicis longus (ext. ossis metacarpi pollicis) is inserted into radial side of base of 1st metacarpal. **Extensor pollicis brevis** is inserted into dorsum of base of 1st phalanx of thumb. These two cross radial artery superficially at wrist-joint, and form antero-lateral boundary of hollow at side of wrist (anatomical snuff-box).

Extensor carpi radialis longus is inserted into radial side of dorsum of base of 2nd metacarpal. **Ext. carpi rad. brevis** is inserted into radial side of dorsum of base of 3rd metacarpal, and usually also into ulnar side of dorsum of 2nd.

Extensor pollicis longus crosses ext. carpi rad. brevis and longus and radial artery at wrist, and runs on to insertion into dorsum of base of 2nd phalanx of thumb. With ext. carpi rad. longus it forms dorso-medial boundary of hollow on side of wrist.

Extensor digitorum communis breaks up into tendons at distal end of radius. On dorsum of hand the diverging tendons are connected by bands, called *punctura tendinum*, and tendon for little finger may not separate till near head of metacarpal. On dorsum of 1st phalanx each tendon broadens out to form **dorsal extensor expansion**, which is joined at the sides by tendons of lumbrical and interossei. At distal end of phalanx it splits into three. Middle piece is inserted into dorsum of base of middle phalanx, the two outlying pieces run on, join each other along their contiguous margins, and are inserted into dorsum of base of 3rd phalanx. The tendons take the place of fibrous capsule on dorsum of metacarpo-phalangeal and interphalangeal joints. **Extensor indicis proprius** runs along ulnar side of tendon of communis to index, and joins it to form extensor expansion.

Extensor digiti quinti proprius divides into two slips which reunite at head of metacarpal after tendon from ext. communis has joined radial slip. Insertion is like that of communis.

Extensor carpi ulnaris is inserted into ulnar side of base of 5th metacarpal.

Arteries are deep to tendons on dorsum of wrist and hand, and have been described already in this section (p. 154).

CLASSIFICATION OF MUSCLES OF UPPER LIMB

In the foregoing account the muscles of the upper limb have been classified, for the most part, according to the regions which they occupy, but the following grouping, based upon their connections and the joints upon which they act, is in some respects more instructive.

Muscles extending from **axial skeleton to shoulder girdle**, acting

on *scapula* and *clavicular joints*. Trapezius, rhomboideus major, rhomboideus minor, levator scapulæ, serratus anterior, pectoralis minor, subclavius.

From **axial skeleton to humerus**, acting on *shoulder-joint*. Pectoralis major, latissimus dorsi.

From **shoulder girdle to humerus**, acting on *shoulder-joint*. Deltoid, coraco-brachialis, subscapularis, supraspinatus, infraspinatus, teres minor, teres major.

From **shoulder girdle to ulna**, acting on *shoulder and humero-ulnar joints*. Triceps (long head).

From **shoulder girdle to radius**, acting on *shoulder, humero-radial and radio-ulnar joints*. Biceps.

From **humerus to ulna**, acting on *humero-ulnar joint*. Triceps (medial and lateral heads), anconæus, brachialis.

From **humerus to radius**, acting on *humero-radial and radio-ulnar joints*. Brachio-radialis, pronator teres (arises from ulna also), supinator (arises chiefly from ulna, acts almost exclusively on radio-ulnar joints).

From **humerus to carpus**, acting on *intercarpal* (pisiform) and *radio-carpal joints* and slightly on *elbow*. Flexor carpi ulnaris (arises chiefly from ulna).

From **humerus to palmar aponeurosis**, acting chiefly on *radio-carpal joint*, slightly on *carpo-metacarpal, intercarpal, radio-ulnar, and elbow joints*. Palmaris longus.

From **humerus to metacarpus**, acting on *carpo-metacarpal, intermetacarpal, intercarpal, radio-carpal, elbow joints*. Extensor carpi ulnaris, ext. carpi radialis longus, ext. carpi rad. brevis, flexor carpi radialis. (The latter two act slightly on radio-ulnar also.)

From **humerus to phalanges**, acting on *interphalangeal, metacarpo-phalangeal, carpo-metacarpal, intercarpal, radio-carpal, and elbow joints*. Flexor digitorum sublimis (from radius and ulna also), ext. dig. communis, ext. digiti quinti (slightly on radio-ulnar also).

From **ulna to radius**, acting on *radio-ulnar joints*. Supinator, pronator quadratus, pronator teres (arises also from humerus and acts also on humero-radial joint).

From **radius and ulna to metacarpus**, acting on *carpo-metacarpal, intercarpal, radio-carpal joints*. Abductor pollicis longus.

From **bones of forearm to phalanges**, acting on *interphalangeal, metacarpo-phalangeal, carpo-metacarpal, intercarpal, radio-carpal joints*. Flexor digitorum profundus from ulna, flexor pollicis longus from radius, flexor dig. sublimis from radius and ulna (from humerus also). Extensor pollicis brevis from radius, ext. pollicis longus from ulna (acts slightly on radio-ulnar also); ext. indicis proprius from ulna.

From **carpus to metacarpus**, acting on *carpo-metacarpal joints*. Opponens pollicis and opponens digiti quinti.

From **carpus to phalanges**, acting on *metacarpo-phalangeal and*

carpo-metacarpal joints. Abductor and flexor pollicis brevis, abductor and flexor dig. quinti brevis, adductor pollicis (also from metacarpus).

From **metacarpus to phalanges**, acting on *metacarpo-phalangeal* and *interphalangeal joints*. Seven interossei, interosseus primus volaris (acting only on metacarpo-phalangeal), adductor pollicis (see paragraph next above).

FASCIÆ AND MUSCLES OF INFERIOR EXTREMITY

FASCIÆ AND MUSCLES OF THIGH AND BUTTOCK

Superficial fascia in buttock is very thick and usually loaded with fat. It contains: (1) small unnamed cutaneous vessels; (2) lateral divisions of *posterior branches*, posterior primary divisions of upper three **lumbar nerves**, descending over iliac crest, in front of post. sup. iliac spine; (3) branches of lateral divisions of *posterior branches* of upper three **sacral nerves**, piercing origin of gluteus maximus from sacro-tuberous lig. and extending laterally; (4) **perforating cutaneous branch** of 2nd and 3rd sacral (ant. branches), piercing sacro-tuberous lig. and gluteus maximus, and turning upwards into buttock; (5) branches of **posterior cutaneous nerve** of thigh (small sciatic), turning round lower border of gluteus maximus and running upwards into buttock; (6) posterior branch of **lateral cutaneous nerve**, turning dorsally and distally into lower part of buttock; (7) *lateral cutaneous* (iliac) branch of **last thoracic nerve**, descending over iliac crest, anterior to tubercle of crest; (8) *lateral cutaneous* (iliac) branch of **ilio-hypogastric**, descending over tubercle of crest.

In groin the superficial fascia is divided into two layers and contains superficial branches of femoral artery and their companion veins, and lymph glands. See Fascia of Abdomen, p. 240.

In the thigh the superficial fascia is thickest usually on the medial side. It contains: (1) small unnamed cutaneous vessels; (2) **great saphenous vein**, leaving leg and entering thigh at medial side of knee, and extending to fossa ovalis (saphenous opening); (3) **lumbo-inguinal nerve** (crural branch of genito-crural), in proximal part of front of thigh; (4) terminal branches of **ilio-inguinal nerve**, over medial part of proximal part of front of thigh; (5) branches of **medial cutaneous nerve** and of cutaneous branch of **obturator**, near great saphenous vein, in distal $\frac{2}{3}$ of thigh; (6) the two divisions of **intermediate** (middle) **cutaneous nerve**, in distal $\frac{2}{3}$ of front of thigh; (7) branches of **lateral cutaneous nerve**, on both anterior and lateral aspects of thigh; (8) branches of **posterior cutaneous nerve** (small sciatic), on posterior and medial aspects of thigh.

Deep fascia enveloping thigh and buttock is called **fascia lata**

Weakest on medial side, strongest on lateral side of thigh. Strong also in anterior part of buttock and over popliteal fossa. *Attached proximally* to iliac crest, dorsum of sacrum and coccyx, sacrotuberous ligament (great sacro-sciatic), ischium, margins of pubic arch, symphysis and crest, inguinal ligament of Poupart. *Distally* to condyles of femur and tibia, head of fibula, capsule of knee-joint. In buttock it splits to enclose glutæus maximus. In thigh it sends in septa to be attached to linea aspera and epicondylar lines:—**Lateral intermuscular septum**, between extensors and flexors, gives attachment to vastus lateralis and intermedius by its ant. surface, glutæus maximus, short head of biceps by its post. surface. **Medial intermuscular septum**, between extensors and adductors; fused distally with adductor magnus and longus, continuous proximally with fascia pectinea, covering pectineus; completes sheaths of gracilis and sartorius. Fascia under sartorius is much thickened in middle third of thigh, where it binds vastus medialis to adductor longus and magnus, and forms fibrous roof of adductor canal (Hunter's).

Tractus iliotibialis (ilio-tibial band) is the thickened lateral part of fascia lata, extending from iliac crest to lateral condyle of tibia, capsule of knee, and head of fibula. Proximal part receives insertion of greater portion of glutæus maximus, and splits to ensheath and receive insertion of tensor fasciæ latæ, deeper layer being connected with reflected head of rectus femoris and capsule of hip-joint.

Fossa ovalis (saphenous opening) (see p. 165) is an oval aperture in fascia lata, just below medial end of inguinal ligament (Poupart). It is closed in by a thin fascia called **fascia cribrosa** (cribriform fascia).

Femoral sheath is formed by fascia lining interior of abdomen—fascia transversalis anteriorly, fascia iliaca posteriorly—being prolonged into thigh around femoral vessels for $1\frac{1}{2}$ in. before fusing with their coats. It is divided by 2 antero-posterior septa into a lateral compartment for femoral art., an intermediate for femoral vein, and a medial compartment called **femoral canal**. The relations of these are given on p. 167.

MUSCLES ON ANTERIOR ASPECT OF THIGH

Sartorius lies superficially on front of thigh and medial side of thigh and knee. **Origin** (fl.): anterior superior iliac spine and half of notch below. **Insertion**: by aponeurotic tendon into proximal part of medial surface of tibia, anterior to gracilis and semitendinosus (from which it is separated by bursa), and by expansions into capsule and tibial collateral ligament of knee, and fascia of leg. **Nerve**: 1., 3, 4, through femoral (ant. crural).¹ It flexes and rotates tibia medially; flexes, abducts, and rotates thigh laterally.

¹ L. signifies Lumbar.

Quadriceps femoris is composed of 4 muscles :—Rectus femoris, vastus lateralis, v. medialis, v. intermedius. They all extend leg at knee-joint. Rectus also flexes hip. Each is supplied from L. 3 and 4, through femoral nerve (ant. crural). Patella is a sesamoid bone developed in its tendon, and the real insertion of quadriceps is into tuberosity of tibia by means of lig. patellæ.

Rectus femoris.—Proximal end lies on capsule of hip, under sartorius and tensor fasciæ latæ ; remainder is superficial, and is separated distally from shaft of femur by bursa, which communicates with knee-joint. **Origin** : by 2 tendinous heads : *straight head* from upper part of anterior inferior iliac spine. *Reflected head* from groove on dorsum ilii, above acetabulum ; a bursa lies under it. **Insertion** : by tendon, into proximal border of patella.

Vastus lateralis lies on lateral aspect of thigh. **Origin** (fl.-tend.) : (1) anterior surface of capsule of hip-joint ; (2) upper part of inter-trochanteric line ; (3) anterior and lateral aspects of root of trochanter major ; (4) lateral margin of gluteal tuberosity ; (5) proximal part of lateral lip of linea aspera ; (6) lateral intermuscular septum. **Insertion** : into tendon of rectus, proximal and lateral borders of patella, and by expansions which blend with the capsule of knee-joint. A bursa lies between it and the part of gluteus maximus inserted into fascia lata.

Vastus medialis lies on medial side of femur. **Origin** (fl.) : (1) lower part of inter-trochanteric line ; (2) spiral line ; (3) medial lip of linea aspera ; (4) proximal $\frac{2}{3}$ of medial epicondylar line ; (5) medial intermuscular septum and tendons of adductor longus and magnus. **Insertion** : medial border of tendon of rectus, medial and proximal margins of patella, and by expansions into capsule and tibial collateral ligament of knee.

Vastus intermedius (Crureus).—**Origin** (fl.) : (1) proximal $\frac{2}{3}$ or $\frac{3}{4}$ of anterior and lateral surfaces of shaft of femur ; (2) distal part of lateral lip of linea aspera ; (3) proximal part of lateral epicondylar line ; (4) distal part of lateral intermuscular septum. **Insertion** : deep surface of tendons of rectus and other vasti. It is largely covered by, and adherent to, v. lateralis, and is blended to a variable extent with v. medialis. It covers proximal prolongation of synovial stratum of knee and the bursa which lies proximal to knee.

Articularis genu (Subcrureus).—**Origin** : by small fleshy

bundles from distal part of anterior surface of femur. **Insertion**: into synovial stratum of capsule of knee-joint. **Nerve**: L. 3, 4, through femoral. It draws up synovial stratum during extension of knee.

Ilio-psoas consists of iliacus and psoas major. Their nerve supply is from L. 2, 3, 4, directly and through femoral (ant. crural). They flex thigh and can rotate it medially during flexion, and rotate it laterally when it is flexed, and when neck of femur is broken. Psoas flexes vertebral column also. A bursa lies between tendon of psoas and capsule of hip-joint. Femoral artery lies on psoas, femoral vein lies on contiguous margins of psoas and pectineus, femoral nerve lies between psoas and iliacus.

Psoas major lies on posterior wall of abdomen; at side of superior aperture of pelvis; and in middle part of floor of femoral trigone (Scarpa's triangle). **Origin** (fl.): (1) anterior surfaces and lower borders of transverse processes of all lumbar vertebrae; (2) fibro-cartilage above each lumbar vertebra and adjacent margins of bodies of vertebrae, including 12th thoracic; (3) fibrous arches covering lumbar vessels on sides of upper 4 lumbar vertebrae. **Insertion**: by tendon into trochanter minor.

Iliacus lies in iliac fossa and in lateral part of floor of femoral trigone. **Origin** (fl.): circumferential part of iliac fossa, ala of sacrum, ant. sacro-iliac, lumbo-sacral, ilio-lumbar, ilio-femoral ligaments. **Insertion** (fl.): into tendon of psoas major, and into lesser trochanter, and bone distal to lesser trochanter for about an inch.

Psoas minor.—Absent in 40 per cent. of cases. Lies in abdomen, on anterior surface of psoas major. **Arises** by small fleshy belly from lateral margins of 12th thoracic and 1st lumbar vertebrae and fibro-cartilage between them. **Inserted**: by long tendon into pectineal line and eminence, and into fascia covering ilio-psoas. **Nerve**: L. 1, directly. It flexes vertebral column and tightens ilio-psoas fascia.

Pectineus lies in proximal and medial part of floor of femoral trigone. **Origin** (fl.): pectineal border and surface of pubis, lig. lacunare (Gimbernat), fascia covering it. **Insertion** (tend.): proximal $\frac{1}{2}$ of line leading from post. aspect of trochanter minor to linea aspera. **Nerve**: L. 2, 3, through femoral (ant. crural). It flexes, adducts, and rotates thigh laterally.

MUSCLES ON MEDIAL SIDE OF THIGH

Gracilis lies superficially. **Origin** (tend.): margin of symphysis and medial margin of inferior ramus of pubis. **Insertion**: by long tendon into medial surface of tibia, distal to condyle, posterior and distal to sartorius, from which it is separated by bursa, proximal and anterior to semitendinosus. A bursa common to it and semitendinosus separates it from tibial collateral ligament. **Nerve**: 1, 2, 3, 4, through obturator.

It adducts thigh, flexes tibia and rotates it medially.

Adductor longus lies in medial and distal part of floor of femoral trigone, and in floor of adductor canal. **Origin**: by rounded tendon, which is easily palpable, from femoral surface of body of pubis, in angle between symphysis and crest. **Insertion** (tend.): distal two-thirds of medial lip of linea aspera. **Nerve**: 1, 2, 3, through obturator.

It adducts and flexes thigh, and rotates it laterally.

Adductor brevis.—**Origin** (fl.): femoral surface of body and inf. ramus of pubis, below longus, between gracilis and obturator ext. **Insertion** (fl.-tend.): distal $\frac{2}{3}$ of line leading from back of trochanter minor to linea aspera; and proximal part of l. aspera. Pectineus, add. longus, profunda vess. and ant. division of obturator nerve are anterior to it. Add. magnus and post. division of obturator n. are behind it. Ilio-psoas, obturator ext., and medial circumflex vess. are related to supero-lateral border. 1st and 2nd perforating branches of profunda vess. pierce it at insertion. **Nerve**: L. 3, 4, through obturator. Same action as longus.

Adductor magnus lies between flexors and other adductors. **Origin** (fl.): lowest impression on tuber ischii, margin of inf. ramus of ischium, femoral surface of pubic ramus, between brevis and obturator ext. **Insertion** (tend.): (1) posterior surface of femur, medial to gluteal tuberosity; (2) linea aspera; (3) medial epicondylar line and septum; (4) adductor tubercle. An interruption in attachment to epicondylar line, for passage of femoral vessels, is called *hiatus tendineus* (opening in adductor magnus). Posterior border is that part arising from tuber ischi and inserted into adductor tubercle by strong tendon, some of whose fibres run into tibial collateral ligament. **Nerves**: L. 3, 4, through obturator; L. 4, 5, S. 1, through tibial part of sciatic. It adducts and rotates thigh laterally. Ischial part extends hip, pubic part flexes it; upper part of pubic portion is sometimes a separate muscle, called *adductor minimus*.

Obturator externus lies deeply, on front of pelvis, and passes below and behind neck of femur. **Origin** (fl.): infero-medial half of outer surface of obturator membrane and the bone adjoining. **Insertion** (tend.): trochanteric fossa. **Nerve**: L. 3, 4, through obturator. Rotates thigh laterally and abducts and flexes it.

Femoral trigone (Scarpa) is a triangular space on proximal $\frac{1}{3}$ of ant. aspect of thigh. **Base**: inguinal lig. (Poupart). **Lateral border**: sartorius. **Medial border**: medial margin of adductor longus. **Apex** leads into adductor canal. **Floor**: ilio-psoas laterally; add. longus medially and distally; pectineus proximal and lateral to longus; add. brevis, occasionally, between pectineus and longus, and on a posterior plane. **Roof**: fascia lata and f. cribrosa. **Contents**: femoral sheath, including femoral canal; femoral art., with its superficial epigastric and circumflex iliac, ext. pudendal and profunda branches; femoral vein, with its saphenous, profunda, circumflex, and deep ext. pudendal tributaries; femoral (ant. crural) nerve and its branches; lateral cutaneous n.; lumbo-inguinal n. (crural branch of genito-crural); lymphatics; fat.

Adductor canal (Hunter) lies in middle $\frac{1}{3}$ of medial side of thigh, extending from apex of femoral trigone to the opening in adductor magnus, through which femoral vessels enter popliteal fossa. **Boundaries**: *antero-lateral*, vastus medialis; *antero-medial*, fascial bridge uniting v. medialis to add. longus and magnus, and covered by sartorius; *postero-medial*, add. longus and magnus. **Contents**: femoral vessels, their musculo-articular and saphenous branches (anastomotic, deep and superficial); saphenous n.; n. to vastus medialis.

Relations in Femoral Trigone and Adductor Canal

(Many of the structures are followed beyond the limits of these spaces.)

Superficial fascia over femoral trigone and front of thigh contains various cutaneous vessels and nerves and lymph glands, which are detailed later. In proximal part of thigh it is subdivided into a superficial fatty part continuous with superficial fascia over rest of body, and a deeper membranous layer continuous above with superficial layers, attached below to medial half of inguinal lig. or deep fascia just below it, and to fascia lata a little distal to lateral half of inguinal lig. Superficial vessels and lymph glands lie between the layers.

Deep fascia or fascia lata, where it roofs in femoral trigone, is perforated by superficial circumflex iliac and superficial epigastric arteries and lumbo-inguinal nerve; and presents an opening called *fossa ovalis*, closed in by a thin fascia, called *fascia cribrosa*, which is perforated by great saphenous vein, numerous lymph vessels, superficial ext. pudendal art., and sometimes by superficial epigastric art.

Fossa ovalis (saphenous opening), oval in shape, $1\frac{1}{2}$ inches long, $\frac{1}{2}$ inch wide, situated just below medial end of inguinal lig. (Poupart), is bounded laterally, proximally and distally by a strongly curved, sharp **falciform margin**, proximal and distal parts of which are called superior and inferior horns. *Superior horn* lies across femoral vein and femoral (crural) canal, and ends medially by blending with femoral surface of lig. lacunare (Gimbernat). *Inferior horn* crosses femoral vein and ends in the fascia covering pectineus. A thickened ridge of fascia covering pectineus extends from horn to horn and forms the medial margin of the fossa. Femoral artery lies usually posterior to lateral margin, femoral vein opposite the opening, and saphenous vein turns over the inferior horn into the opening to join femoral vein.

Proximal superficial subinguinal lymph glands lie between layers of superficial fascia, parallel to, and just below inguinal lig. They drain back of thigh, lateral side of thigh and buttock, and abdominal wall below the level of umbilicus, penis, scrotum, external female genitals, lower end of vagina, perineum, anal canal, anus; and send efferent lymph vessels to deep subinguinal and iliac glands.

Distal superficial subinguinal lymph glands lie along proximal end of great saphenous vein, and along medial side of fossa ovalis (saphenous opening). They drain superficial structures of greater part of lower limb; and send efferents to deep subinguinal and iliac glands.

Deep subinguinal lymph glands lie on medial side of proximal end of femoral vein, one occupying femoral (crural) canal. They drain deep parts of thigh and penis; receive efferents from inguinal and superficial inguinal glands, and send efferents to iliac glands.

Lateral cutaneous nerve of thigh arises from 2nd and 3rd lumbar nerves; appears at lateral border of psoas major, above iliac crest, runs to ant. sup. iliac spine across iliacus; passes posterior to lateral end of inguinal lig. to enter lateral angle of femoral trigone; leaves it at once by passing superficial or deep to sartorius, or through it, descends in ridge of deep fascia, pierces it 4 inches distal to ant. sup. spine; gives a **posterior branch** to skin of lower part of buttock and adjoining lateral side of thigh, and an **anterior branch** to skin of lateral part of front of thigh, as far as knee.

Genito-femoral nerve (genito-crural) arises from 1st and 2nd lumbar nerves; pierces psoas major, descends on its anterior surface, divides at variable point into external spermatic and lumbo-inguinal branches. **External spermatic nerve** (genital branch of genito-crural) runs down upon termination of ext. iliac artery, enters inguinal canal, supplies cremaster muscle, ends in skin of scrotum or labium majus and adjacent part of thigh. **Lumbo-inguinal nerve** (crural branch of genito-crural) enters femoral trigone on lateral side of femoral artery; pierces deep fascia a little distal to inguinal lig. (Poupart), and supplies skin of proximal part of thigh.

Ilio-inguinal nerve arises from 1st lumbar nerve, appears at

lateral border of psoas, crosses quadratus lumborum, pierces transversus abdominis, runs between muscles of abdominal wall, becomes superficial by passing through subcutaneous inguinal ring and piercing external spermatic fascia; ends in skin above symphysis, over proximal and medial part of femoral trigone, of upper part of scrotum and penis, or labium majus.

Femoral nerve (anterior crural) arises from 2nd, 3rd, 4th lumbar nerves, posterior to origin of obturator; appears at lateral border of psoas, gives branches to psoas and iliacus; and, descending between them, it enters femoral trigone from behind inguinal lig., $\frac{1}{2}$ inch, or less, lateral to femoral artery, and very soon breaks up into branches: *Muscular branches* to pectineus, sartorius, rectus femoris, vastus lateralis, intermedius (crureus) and medialis, articularis genu (suberureus). *Cutaneous branches*: intermediate and medial cutaneous nerves, saphenous nerve. *Articular branches*: none directly, but nerve to rectus femoris supplies hip, and nerves to vasti are continued in them to knee.

Branch to pectineus runs distally and medially between psoas and femoral sheath. *Branches to sartorius* descend to it, in company with intermediate cutaneous. *Branch to rectus femoris* enters its deep surface, after passing under cover of sartorius. *Branch to vastus lateralis* passes under cover of sartorius and rectus femoris and runs, in company with descending branch of lateral circumflex art., along anterior border of the muscle, before entering deep surface. *Branches to v. intermedius* (crureus) pass to it under cover of sartorius and rectus, and send a twig to articularis genu (suberureus). *One branch to v. medialis* enters it high up; another runs along lateral side of femoral artery into adductor canal, before entering the muscle.

Intermediate cutaneous nerve (middle cutaneous) consists of *medial* and *lateral branches*. Lateral branch pierces sartorius, and both pierce deep fascia at junction of proximal and middle thirds of thigh, and extend as far as medial side of knee.

Medial cutaneous nerve runs distally and medially across femoral vessels; gives twigs to skin of proximal part of thigh, and divides into anterior and posterior branches. *Anterior branch* pierces deep fascia and supplies skin in distal $\frac{1}{3}$ of medial side of thigh, and over medial part of patella. *Posterior branch* pierces deep fascia at medial side of knee, posterior to saphenous nerve and sartorius, and supplies skin in proximal part of leg.

Saphenous nerve, at first lateral to femoral artery, leaves femoral trigone, and enters adductor canal, where it lies on anterior aspect of femoral artery; leaves canal by passing from under cover of the distal edge of its fibrous roof, accompanied by saphenous artery (superficial branch of anastomotica); sends its infra-patellar branch through sartorius and deep fascia to skin over patella and lig. patellæ; emerges from under cover of sartorius at its posterior border, pierces deep fascia at medial side of knee between sartorius and gracilis; accompanies

great saphenous vein, lying on its posterior aspect, along medial side of leg; passes in front of medial malleolus, and extends as far as middle of medial border of foot.

Obturator or subsartorial plexus lies on fibrous roof of adductor canal, under cover of sartorius; consists of branches from saphenous, intermediate cutaneous, and cutaneous branch of obturator, and supplies neighbouring skin.

Great saphenous vein begins by union of medial end of dorsal venous arch of foot with dorsal digital veins of hallux; extends proximally, anterior to medial malleolus, obliquely across distal part of medial surface of tibia, then immediately posterior to medial border of tibia, and medial condyle of femur; inclines anteriorly and laterally in thigh, pierces fascia cribrosa (cribriform fascia) just above inferior horn of fossa ovalis (saphenous opening), and ends in femoral vein. It has 8 to 20 valves. It communicates with deep veins. It receives numerous unnamed tributaries, and just before piercing fascia cribrosa it receives the superficial external pudendal, epigastric and circumflex iliac veins. Saphenous nerve accompanies it in leg and foot.

Femoral sheath encloses first $1\frac{1}{2}$ inches of femoral vessels. It is formed by the fascia transversalis and ilioaca, which are prolonged over the vessels from ant. and post. abdominal walls, respectively, to form the anterior and posterior walls of the sheath. Psoas, pectineus, nerve to pectineus, and sometimes profunda artery, are posterior to it. Anterior to it are the fascia lata and f. cribrosa. It is pierced by first branches of femoral artery. Lumbo-inguinal nerve (crural branch of genito-crural) lies in proximal part of its lateral wall. It is funnel-shaped and is divided by two antero-posterior septa into a lateral compartment for femoral artery, an intermediate for femoral vein, and a medial compartment called femoral canal.

Femoral canal (crural canal) lies on pectineus, under cover of fascia cribrosa and superior horn of fossa ovalis. Femoral hernia enters thigh through it. It is funnel-shaped, about $\frac{1}{2}$ inch long, and $\frac{1}{2}$ inch wide at mouth of funnel, and contains a lymph gland. **Femoral ring** (crural ring) is the mouth or proximal end of femoral canal, and opens into abdomen. It is plugged by a pad of fat called *femoral septum* (septum crurale). Ring is bounded *anteriorly* by inguinal ligament, which separates it from spermatic cord, *medially* by lig. lacunare (Gimbernat); *posteriorly* by pecten of pubis (pectineal line) and pectineus; *laterally* by femoral vein. Inferior epigastric artery lies between it and abdominal inguinal ring (int. abdominal), and its "abnormal" obturator branch, when present, descends across the ring, or along its medial side.

A **femoral hernia** descends into femoral canal and turns forwards through fossa ovalis. Anterior part of the hernia is then pressed upon and retarded by superior horn of falciform margin, the posterior part, being pushed onwards, hooks round the horn, and the hernia ascends over inguinal ligament. *Coverings* of the hernia are (1)

femoral septum, (2) the lymph gland, (3) anterior wall of femoral canal, (4) fascia cribrosa, (5) superficial fascia, (6) skin.

Femoral artery begins as a continuation of ext. iliac, posterior to inguinal lig., mid-way between ant. sup. iliac spine and symphysis pubis; runs distally through femoral trigone and adductor canal, and ends at junction of middle and distal thirds of thigh by passing through hiatus tendineus (opening) in adductor magnus and becoming popliteal artery. Position is indicated by proximal $\frac{2}{3}$ of line drawn from point of origin to adductor tubercle, when thigh is slightly flexed, abducted and rotated laterally.

Relations in Femoral Trigone.—Femoral sheath surrounds proximal $1\frac{1}{2}$ inches. *Anterior to it* are fasciæ and medial cutaneous nerve. *Lateral to it* are femoral nerve and its branches, nerve being separated by small piece of psoas; lombo-inguinal nerve in lateral wall of sheath. *Posterior to it* are psoas, pectineus, adductor longus, proximo-distally; and sometimes adductor brevis appears between pectineus and longus; nerve to pectineus; a large mass of fat containing profunda and femoral vein. Profunda artery is first lateral and then posterior. Femoral vein is posterior to femoral artery at apex of trigone, but is on its medial side at base of trigone. Psoas separates artery from capsule of hip-joint and head of femur.

Relations in Adductor Canal.—*Within the canal*: saphenous nerve is anterior, nerve to vastus medialis is lateral, femoral vein is posterior, except towards distal end, where it becomes postero-lateral. *Walls of canal*: vastus medialis is antero-lateral; fibrous roof, subsartorial plexus and sartorius are antero-medial; adductor longus and magnus are postero-medial. *Beyond canal*: femur is lateral, and separated only by vastus medialis; profunda vessels are posterior, separated from femoral vessels by adductor longus.

Branches of Femoral Artery.—Unnamed muscular; superficial epigastric and circumflex iliac, superficial and deep external pudendal, all near origin of femoral; profunda femoris; and, in adductor canal, art. genu suprema (anastomotica).

Superficial circumflex iliac artery pierces femoral sheath and fascia lata, and runs along inguinal ligament (Poupart) to ant. sup. iliac spine, where it anastomoses with branches of deep circumflex iliac, of gluteal arteries and of lateral circumflex.

Superficial epigastric artery pierces sheath and fascia lata and passes upwards, superficial to inguinal lig., to anterior abdominal wall.

Superficial external pudendal artery crosses femoral vein, pierces sheath and fascia cribrosa, passes superficial to spermatic cord to reach penis and scrotum.

The veins corresponding to these three superficial arteries end, not in the femoral, but in great saphenous vein.

Deep external pudendal artery crosses femoral vein, pierces sheath, runs medially upon pectineus and adductor longus, pierces deep fascia, and passes deep to spermatic cord to reach penis and scrotum.

Arteria genu suprema (anastomotica) arises near distal end of femoral, and at once divides into a **musculo-articular branch**, which pierces vastus medialis and runs to knee in it, and a **saphenous branch**, which passes out of canal with saphenous nerve and anastomoses with other articular arteries at medial side of knee.

Profunda femoris artery arises $1\frac{1}{2}$ inches distal to inguinal lig., from lateral side of femoral artery; curves backwards and medially, posterior to femoral; leaves femoral trigone by passing posterior to adductor longus, and ends by piercing adductor magnus as 4th perforating. In femoral trigone, iliacus and pectineus are posterior to it. It is first lateral to femoral artery, and is crossed superficially by lateral circumflex vein. Afterwards it is posterior to profunda vein, femoral vein, femoral artery, in that order from behind forwards. After it has left femoral trigone it lies, with profunda vein, close to femur; adductor brevis and magnus are posterior to it, adductor longus is anterior, and separates it from femoral vessels.

Branches of Profunda Femoris.—Unnamed muscular; lateral and medial circumflex; four perforating arteries.

Lateral circumflex artery runs laterally upon iliacus, among branches of femoral (ant. crural) nerve; passes posterior to sartorius and rectus femoris, and divides into three branches: (1) *ascending branch* runs towards ant. sup. iliac spine, under cover of tensor fasciæ latae; (2) *descending branch* runs along anterior border of vastus lateralis to the knee; (3) *transverse branch* sinks into vastus lateralis.

Medial circumflex artery passes backwards between contiguous margins of psoas and pectineus, and then between obturator externus and adductor brevis, sends an acetabular branch through acetabular notch, and along lig. teres, to head of femur; and ends by dividing into deep and superficial branches. **Deep branch** runs along obturator externus, under cover of quadratus femoris, to trochanteric fossa. **Superficial branch** passes backwards between quadratus femoris and adductor magnus, and anastomoses with gluteal arteries and muscular branches of profunda.

Four perforating arteries are given off after profunda has left femoral trigone. They lie close to femur, and pierce muscles and lateral intermuscular septum, to end in vastus lateralis. The second gives nutrient artery to femur; others may do so also. **First** pierces adductor brevis and magnus and gluteus maximus. **Second** pierces adductor brevis and magnus and short head of biceps. **Third** and **fourth** pierce adductor magnus and short head of biceps.

Profunda vein lies anterior to its artery and ends in femoral vein in femoral trigone. It receives tributaries corresponding to branches of artery, except the circumflex veins; these end in femoral vein.

Femoral vein begins as a continuation of popliteal vein at opening in adductor magnus, postero-lateral to artery; enters apex of femoral trigone directly posterior to artery; and ends on medial side of artery, posterior to inguinal lig., by becoming ext. iliac.

Anterior to it : proximally, fascia lata and f. cribrosa, ext. pudendal arteries (the deep artery may be posterior); distally, the femoral artery. *Lateral to it*, distally, are the vastus medialis and femur, proximally, the artery. *Posterior to it* at first is adductor magnus; then add. longus, separating it from profunda vessels; then pectineus (and sometimes add. brevis), separated by profunda vessels and much fat; and lastly the contiguous margins of psoas and pectineus. All these muscles, except psoas, are also *medial to it*; and femoral canal is medial at proximal end.

Tributaries.—Great saphenous; profunda, venæ comites of art. genu suprema (anastomotica), lateral and medial circumflex, deep external pudendal.

MUSCLES OF THE BUTTOCK

Glutæus maximus lies superficially. Coarsest and heaviest muscle of body. **Origin** (fl.): (1) upper part of area on dorsum ilii behind posterior gluteal line; (2) tendon of sacro-spinalis; (3) dorsum of sacrum and coccyx; (4) dorsal surface of lig. sacro-tuberosum (great sacro-sciatic); (5) fascia enveloping it. **Insertion** (tend.): ilio-tibial tract, gluteal tuberosity, lateral intermuscular septum. **Nerve**: L. 5, S. 1, 2, through inferior gluteal. It extends, abducts, and rotates thigh laterally; tightens tractus ilio-tibialis (ilio-tibial band). Lowest fibres adduct thigh.

Structures covered by Glutæus Maximus.—**Medial series**: (1) Structures from which it arises; (2) tuber ischii, bursa intervening; (3) hamstrings and adductor magnus, at origin from tuber.

Intermediate Series: (1) Glutæus medius; (2) superficial branches of superior gluteal vessels; (3) piriformis; (4) sciatic nerve and nerve to quadratus; (5) posterior cutaneous nerve, and (6) inf. gluteal nerve and (7) inf. gluteal vessels; (8) nerve to obturator int.; (9) int. pudendal vess.; (10) pudendal nerve; (11) obturator int. and gemelli; (12) quadratus femoris (obturator ext. and deep branch of medial circumflex art. lie deeply between inf. gemellus and quadratus); (13) superficial branch of medial circumflex vessels; (14) adductor magnus.

Lateral Series: (1) Glutæus medius; (2) trochanter major, bursa intervening; (3) proximal end of vastus lateralis, and the bursa intervening.

Lower border of glutæus max. crosses fold of nates obliquely, from above downwards and laterally.

Glutæus medius lies in upper and anterior part of buttock, posterior $\frac{1}{3}$ being deep to maximus. **Origin** (fl.): dorsum ilii,

between post. gluteal line and iliac crest above, and ant. gluteal line below; fascia covering it. **Insertion** (tend.): postero-superior angle of trochanter major and oblique line leading to antero-inferior angle. **Nerve**: L. 4, 5, S. 1, through sup. gluteal. It abducts thigh. Ant. fibres flex and rotate medially; post. fibres rotate laterally. A bursa lies between it and anterior part of trochanter.

Tensor fasciæ latæ lies superficially between buttock and anterior surface of thigh. **Origin** (fl.): ant. superior iliac spine, part of notch below, crest of ilium for an inch behind. **Insertion**: tractus iliotibialis, between its lamellæ, a little distal to trochanter major. **Nerve**: L. 4, 5, S. 1, through sup. gluteal. It braces tractus iliotibialis, abducts thigh and rotates it medially.

Glutæus minimus lies under cover of medius. **Origin** (fl.): dorsum ilii between ant. and inf. gluteal lines. **Insertion** (tend.): anterior surface of trochanter major and capsule of hip-joint. Bursa lies between it and medial part of anterior surface of trochanter. **Nerve**: L. 4, 5, S. 1, through superior gluteal. Same action as medius.

Piriformis lies partly in pelvis, partly in buttock. **Origin** (fl.): pelvic surfaces of 2nd, 3rd, 4th pieces of sacrum, between and lateral to foramina and sometimes medial to them; upper margin of greater sciatic notch; pelvic surface of lig. sacro-tuberosum (great sacro-sciatic). **Insertion**: by round tendon into upper margin of trochanter major. **Nerves**: S. 1, 2, directly.

It abducts flexed thigh; laterally rotates extended thigh.

Obturator internus lies in pelvis, on its antero-lateral wall; its tendon lies in buttock, on posterior surface of capsule of hip. **Origin** (fl.): pelvic surface of obturator membrane, margins of foramen obturatum, except at obturator groove; pelvic surface of hip-bone, posterior to and above foramen; fascia covering it. **Insertion**: medial surface of trochanter major, above trochanteric fossa. **Nerve**: L. 5, S. 1, 2, through special nerve. Same action as piriformis.

Pelvic surface of piriformis is in relation to rectum, sacral plexus, branches of hypogastric (int. iliac) vessels. It leaves pelvis through greater sciatic foramen, with sup. gluteal nerve and vessels above it, 6 nerves and 2 sets of vessels (see under glutæus maximus) between it and sup. gemellus and coccygeus. Lies on capsule of hip. Its common peroneal nerve (ext. popliteal) arises directly from sacral plexus, it splits piriformis as it passes out of pelvis.

Pelvic surface of obturator internus is in relation to obturator nerve and vessels, bladder, ovary, levator ani, below which muscle it forms lateral wall of ischio-rectal fossa, and contents of Alcock's canal lie on it. Its tendon turns, at a right angle, outwards through lesser sciatic foramen, and is separated from bone by bursa.

Gemelli supplement obturator int., and lie one above and one below its tendon. They arise from margins of lesser sciatic notch, and are inserted into tendon of obturator internus and medial surface of trochanter. *Superior* is supplied by nerve to obturator internus, *inferior* by nerve to quadratus femoris.

Quadratus femoris lies in lowest part of buttock. **Origin** (fl.-tend.): lateral margin of tuber ischiadicum. **Insertion** (fl.-tend.): into eminence (quadrate tubercle) on inter-trochanteric crest, and into line leading distally from it. **Nerve**: L. 4, 5, S. 1, through special nerve. It adducts thigh and rotates it laterally.

MUSCLES ON POSTERIOR ASPECT OF THIGH

HAMSTRINGS OR FLEXORS

Biceps femoris lies in buttock, back of thigh, and in lateral boundary of popliteal fossa. **Origin**: *Long head*, by tendon from medial of two upper impressions on tuber ischii, in company with semitendinosus; many fibres are continuous with lig. sacro-tuberosum (gt. sciatic). It crosses sciatic nerve. *Short head* (fl.-tend.), from lateral lip of linea aspera, proximal $\frac{2}{3}$ of lateral epicondylic line; lateral intermuscular septum. **Insertion**: by tendon, easily palpable, into head of fibula, lateral condyle of tibia, fascia of leg. Fibular collateral ligament splits it longitudinally and is separated from it by bursa. **Nerves**: *long head*, S. 1, 2, 3, through tibial part of sciatic; *short head*, L. 5, S. 1, 2, through peroneal part. It flexes leg and rotates it laterally; extends thigh.

Semitendinosus lies in buttock, in back of thigh, and on medial side of popliteal fossa. **Origin** (tend.): medial impression on tuber ischii, together with long head of biceps, to which it is joined for 3 inches. **Insertion**: by tendon, felt superficially on medial side of popliteal fossa, into medial surface of tibia, distal to condyle, posterior and distal to gracilis and sartorius, and by expansion into fascia of leg. Bursæ separate it from sartorius and tibial collateral liga-

ment. **Nerve**: L. 5, S. 1, 2, through tibial part of sciatic. It flexes leg and rotates it medially, and extends thigh.

Semimembranosus lies deep to semitendinosus in buttock, in back of thigh, and in medial boundary of popliteal fossa.

Origin (tend.): lateral impression on tuber ischii. Long head of biceps crosses it superficially, distal to its origin.

Insertion: by tendon, felt more deeply than semitendinosus on medial side of popliteal fossa, into (1) groove on posterior surface of lateral condyle of tibia, (2) tibial collateral ligament, (3) fascia covering popliteus, (4) capsule of knee (oblique popliteal lig.). Bursæ lie under it at insertion, and between it and medial head of gastrocnemius. **Nerve**: L. 4, 5, S. 1, through tibial part of sciatic. Same actions as semitendinosus.

FASCIÆ AND MUSCLES OF LEG AND FOOT

Superficial fascia contains: (1) small unnamed cutaneous vessels; (2) **small saphenous vein**, running proximally from posterior aspect of lateral malleolus to pierce deep fascia roofing popliteal fossa; (3) **great saphenous vein**, running from ant. aspect of medial malleolus, across tibia, and proximally just posterior to its medial margin; (4) **saphenous nerve**, accompanying great saphenous vein; (5) terminal branches of **medial cutaneous nerve of thigh**, on proximal part of medial side of leg; (6) **posterior cutaneous nerve of thigh** (small sciatic), piercing roof of popliteal fossa and supplying proximal half of calf + leg; (7) **medial sural nerve** (ramus communicans tibialis), piercing deep fascia to join (8) the **ramus anastomoticus peronæus** (i. communicans fibularis) to form (9) the **nervus suralis** (short saphenous), which accompanies small saphenous vein in distal part of leg; (10) **lateral sural nerve**, on antero-lateral aspect of proximal part of leg; (11) two terminal branches of **superficial peroneal** (musculo-cutaneous), piercing deep fascia and descending in distal third of anterior surface of leg.

Deep fascia envelops leg. Attached to lig. patelle and bony points about knee. Strengthened by expansions from tendons of sartorius, gracilis, semitendinosus, biceps. Blends with periosteum of medial surface of tibia. Sends in septa between muscles, and these get partial origin from them. Two of these are named: (1) **Anterior intermuscular septum** is attached to anterior crest of fibula, between extensor dig. longus and peronæus tertius anteriorly, peronæus longus and brevis posteriorly. (2) **Posterior intermuscular septum** is attached to lateral crest of fibula, between peronæi anteriorly, soleus and flexor hallucis longus posteriorly.

Deep fascia is thickened around ankle to form ligaments which

hold tendons in position, and also help to bind together the bones to which they are attached :—

(1) **Lig. laciniatum** (internal annular) is attached to medial malleolus and medial process of tuber calcanei. (See also p. 182.)

(2) **Lig. transversum cruris** (ant. annular, upper band) is attached to distal ends of anterior crests of tibia and fibula. About an inch in depth. Often not clearly defined from adjoining deep fascia. Holds down extensors and tibialis anterior; the tibialis anterior alone has a mucous sheath at that level.

(3) **Lig. cruciatum cruris** (ant. annular, lower band), occasionally X-shaped, usually Y-shaped. Stem is attached to anterior part of dorsal surface of calcaneus; proximal limb is attached to medial malleolus; distal limb blends with fascia on medial side of foot. (See also p. 188.)

Thickened fascia attached to lateral malleolus and calcaneus, which binds down peroneal tendons, is called **peroneal retinacula** (ext. annular ligament). **Superior retinaculum** holds them against posterior surface of lateral malleolus and is lined with single mucous sheath. **Inferior retinaculum** binds them to lateral surface of calcaneus, and is divided by septum, attached to trochlear process (peroneal tubercle), into compartments for each tendon, each lined with separate sheath.

On dorsum of foot deep fascia is thin. On sole it is called **aponeurosis plantaris**. Its **intermediate part**, covering flex. dig. brevis, is very strong and important. Triangular in shape. *Apex* is attached to medial process of tuber calcanei. Septa are sent upwards from *margins* along sides of flex. dig. brevis. *Base* divides into five slips which are united to the proximal ends of fibrous flexor sheaths. On the toes deep fascia forms fibrous flexor or digital sheaths, like those on fingers. (See also pp. 181, 182.)

MUSCLES ON ANTERIOR ASPECT OF LEG AND DORSUM OF FOOT

Tibialis anterior lies immediately lateral to tibia. **Origin** (fl.): lateral condyle and proximal $\frac{2}{3}$ of lateral surface of tibia; interosseous membrane, fascia covering it, and septum between it and ext. dig. longus. **Insertion**: by tendon, into medial surface of 1st cuneiform and base of 1st metatarsal. **Nerve**: L. 4, 5, S. 1, through deep peroneal (ant. tibial). It dorsi-flexes and inverts foot.

Extensor digitorum longus lies lateral to tibialis ant. **Origin** (fl.): lateral condyle of tibia, proximal $\frac{2}{3}$ of anterior part of medial surface of fibula, proximal part of interosseous membrane, fascia covering it, and septum on each side.

Insertion: 2nd and 3rd phalanges of the lateral four toes.
Nerve: L. 4, 5, S. 1, through deep peroneal (ant. tibial). It extends toes, dorsi-flexes foot.

Peronæus tertius is continuous with ext. dig. longus.
Origin (fl.): distal $\frac{1}{3}$ of ant. part of medial surface of fibula, distal part of interosseous membrane, anterior intermuscular septum. Tendon passes under lig. cruciatum (ant. annular), in same sheath as ext. dig. longus, and is **inserted** into base of 5th metatarsal. **Nerve:** L. 4, 5, S. 1, through deep peroneal (ant. tibial). It everts and dorsi-flexes foot.

Extensor hallucis longus lies between, and is partly hidden by, tibialis ant. and ext. dig. longus. **Origin (fl.):** middle $\frac{2}{3}$ of ant. part of medial surface of fibula, and corresponding part of interosseous membrane. Crosses anterior tibial vessels and deep peroneal nerve, and its tendon runs on to be **inserted** into base of 2nd phalanx of great toe. **Nerve:** L. 4, 5, S. 1, through deep peroneal. It extends great toe, dorsi-flexes foot.

Extensor digitorum brevis (see p. 187).

MUSCLES ON LATERAL ASPECT OF LEG

Peronæus longus lies superficially in front of the calf. **Origin (fl.):** head and proximal $\frac{2}{3}$ of lateral surface of shaft of tibia, intermuscular septa, fascia covering it. Tendon is enclosed in mucous sheath. It lies behind brevis on posterior surface of lateral malleolus, and below brevis on lateral surface of calcaneus. It traverses groove on plantar surface of cuboid, and is **inserted** into lateral side of base of 1st metatarsal and 1st cuneiform near sole (cf. tibialis anterior). **Nerve:** L. 4, 5, S. 1, through superficial peroneal (musculo-cutaneous). It everts and extends foot.

Peronæus brevis lies deep to longus, and anterior to it. **Origin (fl.):** distal $\frac{1}{3}$ of lateral surface of tibia; intermuscular septa. Tendon, enclosed in sheath on post. surface of lateral malleolus and on lateral surface of calcaneus, is **inserted** into lateral side of tuberosity on base of 5th metatarsal. **Nerve and actions,** same as longus.

SUPERFICIAL MUSCLES ON POSTERIOR ASPECT OF LEG

Triceps suræ consists of gastrocnemius and soleus, which are **inserted** by common tendon, called tendo calcaneus

(Achillis), seen above heel, into middle area of posterior surface of calcaneus (os calcis); it is separated from upper area by bursa and from bones of leg and ankle-joint by an interval containing fatty areolar tissue.

It extends foot; gastrocnemius also flexes knee.

Gastrocnemius lies superficially in calf. Its two heads form distal boundaries of popliteal fossa and lie on post. part of capsule of knee, from which medial head is partly separated by bursa, which may communicate with interior of joint and with bursa between semimembranosus and gastrocnemius. Bursa deep to lateral head is less common. A sesamoid cartilage may be developed in lateral head.

Origin (tend.): *Lateral head*: distal end of epicondylar line, adjoining lateral surface of lateral condyle, capsule of knee-joint. *Medial head*: rough mark on popliteal surface of femur, proximal to medial condyle, behind adductor tubercle.

Nerves: S. 1, 2, through tibial.

Soleus lies under cover of gastrocnemius. **Origin** (fl.-tend.): post. surface of head and proximal $\frac{1}{3}$ of shaft of fibula; tendinous arch across popliteal vessels and tibial nerve; popliteal line and middle $\frac{1}{3}$ of medial margin of tibia.

Nerves: L. 5, S. 1, 2, through two branches from tibial.

Plantaris.—Sometimes absent. Lies between gastrocnemius and soleus. **Origin** (fl.): distal part of lateral epicondylar line and adjoining popliteal surface; oblique popliteal ligament. **Insertion**: by tendon, the longest in body and capable of great transverse stretching, into medial process of tuber calcanei, *or* medial side of tendo calcaneus, *or* lig. laciniatum (int. annular). **Nerve**: L. 4, 5, S. 1, through tibial. It supplements triceps suræ.

DEEP MUSCLES ON POSTERIOR ASPECT OF LEG

Popliteus lies in distal part of floor of popliteal fossa. **Origin**: ant. end of popliteal groove on lateral surface of lateral condyle of femur, by tendon which lies within fibrous capsule of knee, between fibular collateral ligament and lateral meniscus, separated from both by synovial sheath derived from membrane of knee. It lies in popliteal groove only in extreme flexion; lies on its distal edge during extension. Pierces post. part of capsule of knee, becomes fleshy, and is inserted into popliteal line of tibia and surface

proximal to that, and into fascia covering it. **Nerve** : L. 4, 5, S. 1, through tibial. It flexes leg and rotates it medially.

Flexor digitorum longus lies on tibial side of back of leg, and in sole of foot. **Origin** (fl.) : Middle $\frac{3}{5}$ of posterior surface of tibia, distal to popliteal line and medial to vertical line ; fascia covering tibialis posterior. Tendon passes on to superficial or posterior aspect of tibialis posterior, proximal to malleolus, crossing it to lie on its lateral side on most medial part of back of ankle-joint, under cover of lig. laciniatum (int. annular), enclosed in separate mucous sheath. Passes superficial to edge of sustentaculum tali : enters sole, crosses flex. hallucis longus superficially and gets a slip from it. Receives insertion of quadratus plantæ, and divides into 4 tendons for lateral 4 toes ; and from these tendons lumbrical muscles arise. Each tendon enters fibrous flexor sheath, enclosed in mucous (synovial) sheath ; perforates corresponding tendon of flexor brevis, and is inserted into base of 3rd phalanx. **Nerve** : S. 1, 2, through tibial. It flexes toes, extends ankle-joint (plantar flexion). (See also p. 183.)

Flexor hallucis longus lies on fibular side of back of leg and in sole of foot. **Origin** (fl.) : Distal $\frac{3}{4}$ of post. surface of fibula, distal part of interosseous membrane, posterior intermuscular septum, fascia over tibialis posterior. Tendon is ensheathed in most lateral compartment of lig. laciniatum ; crosses flex. dig. longus dorsally in sole and gives it a slip ; runs on to enter fibrous flexor sheath, and is inserted into base of 2nd phalanx of great toe. **Nerve** : L. 5, S. 1, 2, through tibial. It flexes great toe, extends foot.

Tibialis posterior is deepest muscle in back of leg, between long flexors. **Origin** (fl.) : Posterior part of medial surface of fibula ; lateral condyle and proximal $\frac{2}{3}$ of post. surface of tibia, distal to popliteal line and lateral to vertical line ; interosseous membrane ; fascia covering it. Tendon is ensheathed in most medial compartment of lig. laciniatum ; and is inserted chiefly into tuberosity of navicular and 1st cuneiform ; by slips also into all other tarsals except talus, and into bases of 2nd, 3rd, 4th metatarsals. **Nerve** : S. 1, 2, through tibial. It inverts and extends foot.

Mucous or synovial sheaths of tendons around ankle begin 1 inch proximal to "annular" ligaments. In the case of tendons inserted into tarsal and metatarsal bones they extend to insertion (except sheath of peroneus longus) ; in the case of those inserted into phalanges they extend to middle of sole.

Muscles of Sole of Foot (see pp. 182-185).

Popliteal fossa (space) is the lozenge-shaped hollow at back of knee; longer diameter vertical. **Roof**: popliteal fascia, pierced by post. cutaneous n. (small sciatic) and small saphenous vein. **Floor**: popliteal surface of femur, oblique popliteal ligament, popliteus and its fascia. **Boundaries**: *Proximal lateral*: biceps. *Distal lateral*: lateral head of gastrocnemius, plantaris. *Proximal medial*: semitendinosus, semimembranosus, supplemented by sartorius, gracilis and tendon of adductor magnus. *Distal medial*: medial head of gastrocnemius. **Contents**: Popliteal art. and its branches. Popliteal vein and its tributaries, including small saphenous. Tibial and common peroneal nerves (int. and ext. popliteal) and certain of their branches. Posterior cutaneous nerve of thigh (small sciatic). Geniculate branch of obturator nerve. Lymph-glands and fat.

Relations in Popliteal Fossa

Popliteal artery is the continuation of femoral at opening in adductor magnus, at proximal part of medial boundary of popliteal fossa. It runs distally and laterally to the interval between condyles of femur, and then vertically, leaving the fossa at its distal angle, to end at distal border of popliteus by dividing into ant. and post. tibial. Its **branches**, besides its terminals, are muscular, cutaneous, and five articular—two medial, two lateral, and one middle.

Popliteal vein begins at distal border of popliteus, medial to the artery, by the union of venæ comites of ant. and post. tibial arteries. It crosses posterior aspect of artery to lie postero-lateral to it at opening in adductor magnus, where it becomes femoral vein. Its **tributaries** are the small saphenous vein and veins accompanying branches of the artery.

Tibial nerve (int. popliteal), a terminal branch of sciatic, enters the fossa at proximal angle, lateral to popliteal vessels, crosses them on their posterior aspect, and leaves the fossa at its distal angle, medial to both vessels, and is continued into the calf. Its **branches** in the fossa are *medial sural nerve* (ramus communicans tibialis); three *articular branches*; *muscular branches* to both heads of gastrocnemius, plantaris, soleus, and popliteus; the branches to soleus and popliteus arise when nerve is medial to popliteal artery, and they cross posterior to the artery.

Relations of this group—artery, vein, nerve—are:—*Anterior*: the floor of fossa—femur, oblique lig., and popliteus, the artery being next the floor, but separated by fat, especially proximally. *Posterior*: posterior cutaneous nerve of thigh, deep fascia, small saphenous vein; and both heads of gastrocnemius overlap. *Medial*: medial boundary

of fossa, semimembranosus overlapping the vessels; and medial condyle. *Lateral*: Lateral boundary of fossa, lateral condyle, and common peroneal (ext. popliteal) nerve.

Muscular branches of popliteal artery supply muscles of back of thigh and anastomose with muscular and perforating branches of profunda, and some, called **sural arteries**, supply muscles of calf. **Cutaneous twigs** spring from the muscular branches.

Five articular branches anastomose with other arteries around knee-joint. (1) **Medial superior genicular artery** leaves the fossa by passing medially, under cover of adductor magnus tendon, semimembranosus, and semitendinosus, proximal to medial condyle of femur. (2) **Lateral superior genicular artery** runs laterally under common peroneal nerve and biceps tendon, proximal to lateral condyle of femur. (3) **Medial inferior genicular artery** runs distally and medially, distal to medial condyle of tibia, under cover of medial head of gastrocnemius, and then anteriorly under cover of tibial collateral lig. of knee (int. lateral). (4) **Lateral inferior genicular artery** keeps a more proximal level, and passes laterally under cover of plantaris, lateral head of gastrocnemius, common peroneal nerve (ext. popliteal), tibial collateral lig. of knee, and tendon of biceps. (5) **Middle genicular artery** (zygos) pierces oblique lig. to gain interior of joint.

Small saphenous vein begins at dorsal venous arch of foot, ascends on posterior aspect of lateral malleolus and calf of leg, pierces popliteal fascia, and ends in popliteal vein.

Muscular branches of tibial nerve pass directly to the muscles, except the *nerve to popliteus*, which, after crossing popliteal artery, descends and turns round distal border of popliteus to enter its deep or anterior surface. **Articular branches** accompany the middle and the two medial genicular arteries.

Medial sural nerve (ramus communicans tibialis) arises from tibial nerve, and leaves fossa by its distal angle, under cover of deep fascia.

Common peroneal nerve (external popliteal), a terminal branch of sciatic, enters fossa at its proximal angle, from under cover of biceps, runs along medial side of biceps, leaves fossa by its lateral angle, crosses plantaris, lateral head of gastrocnemius, tendon of popliteus, lateral genicular vessels, and lies between tendon of biceps and gastrocnemius on posterior aspect of head of tibia, where it is most easily felt; runs distally and forwards to enter substance of peroneus longus on lateral side of neck of tibia, where it gives off recurrent articular branch, and then divides into superficial and deep branches (musculo-cutaneous and anterior tibial).

Branches of Common Peroneal Nerve in Popliteal Fossa — **Muscular** none. **Two articular branches** accompany lateral genicular arteries. **Lateral sural nerve** passes superficial to lateral head of gastrocnemius and supplies skin on lateral and anterior aspects

of proximal part of leg. **Anastomotic peroneal branch** (ramus communicans fibularis) passes superficial to lateral head of gastrocnemius, pierces deep fascia, joins medial sural branch of tibial nerve to form **nervus suralis** (ext. saphenous), which runs distally along with small saphenous vein to post. aspect of lateral malleolus, and along fibular margin of foot and little toe.

Posterior cutaneous nerve of thigh (small sciatic) enters fossa at proximal angle, under cover of deep fascia; sends a branch through deep fascia over proximal part of fossa; pierces deep fascia itself about middle of fossa, and supplies skin of proximal part of calf.

Geniculate branch of obturator nerve is rarely seen. It emerges from substance of adductor magnus, and runs distally, closely applied to medial side of popliteal artery, to end in capsule of knee.

FOOT AND TOES

Surface Anatomy.—The **malleoli** are readily felt; the lateral malleolus is farther back and reaches a lower level than the medial. **Sustentaculum tali** is felt 1 inch below medial malleolus. One inch, or more, anterior to and below malleolus the **tubercle of navicular** is felt, with greater ease. The ball of the foot is formed by the **metatarso-phalangeal joints**, and is specially prominent at the medial side, on account of greater size of 1st joint, and of the presence of sesamoid bones at that joint. Head, shaft and base of **first metatarsal** are readily palpated along medial side of foot. Between its base and the tubercle of navicular is the **first cuneiform**.

Tendon descending to 1st cuneiform and 1st metatarsal base is **tibialis anterior**; on its fibular side is the smaller tendon of **extensor hallucis longus**. **Dorsalis pedis artery** lies on fibular side of ext. hallucis, from ankle to level of base (*proximal end*) of 1st metatarsal; and **deep peroneal nerve** (ant. tibial) is immediately lateral to the artery. Tendons of **ext. dig. longus** and **peronæus tertius** are on fibular side of artery and nerve. All the tendons are brought into view when the muscles are set into action, and **lig. cruciatum** (lower band of ant. annular) may then be felt below ankle-joint.

The swelling on dorsum of foot, anterior to lateral malleolus, on lateral side of extensor tendons, is the fleshy belly of **ext. dig. brevis**. The knob felt beneath extensor tendons, 1 in. below ankle, antero-medial to lateral malleolus, when toes are pointed and foot inverted, is the supero-lateral part of **head of talus** (astragalus); supero-lateral part of its body may form a prominence near ankle-joint, close to medial side of lateral malleolus.

Tendons of **peronæus longus** and **brevis** may be felt, passing downwards and forwards from posterior surface of lateral malleolus on to lateral surface of calcaneus (os calcis); and between them, below

malleolus, the **trochlear process** (peroneal tubercle) of calcaneus can be felt, when it is well developed. Peronæus brevis, the upper of the two tendons, can be traced to prominent tubercle on **base of fifth metatarsal**, just behind which the tendon of longus turns round the small lateral surface of **cuboid**. Lateral end of **transverse tarsal joint** is $\frac{1}{2}$ inch posterior to base of 5th metatarsal; its medial end is immediately posterior to tubercle of navicular. Base, shaft and head of 5th metatarsal are easily palpated, and **fifth metatarsophalangeal joint** makes a variable prominence on fibular side of foot, a little posterior to base of little toe.

Sole of Foot

Superficial fascia of sole is traversed by fibrous bands dividing fat into lobules. It is thickened on heel, ball of foot, and pulp of toes. On the toes it contains digital vessels and nerves; in the sole it contains vessels and nerves from various sources, and the superficial transverse ligament:—

Medial calcaneal nerve arises from tibial nerve as it lies under cover of hg. laciniatum (int. annular), pierces hg. laciniatum as several branches, which turn laterally, and ramify over plantar surface of heel. They are accompanied by **medial calcaneal branches** of posterior tibial and lateral plantar arteries.

Nervus suralis (short saphenous) formed by medial sural branch of tibial and anastomotic branch of common peroneal nerve (rami communicantes, tibialis and fibularis) descends with small saphenous vein, posterior to lateral malleolus, and along lateral border of foot and little toe, and gives branches to skin of dorsum and sole of foot.

Saphenous branch of femoral nerve (int. crural) runs distally, anterior to medial malleolus, with great saphenous vein, and ends about middle of medial border of foot. It gives branches to skin of dorsum and sole on medial side.

Medial and lateral plantar nerves and arteries send cutaneous branches to intermediate part of sole.

Superficial transverse ligament lies across the roots of the toes and in the webs near their free edges, on the plantar side of digital vessels and nerves.

Deep fascia on sole is called **plantar aponeurosis**. Medial and lateral parts cover abductors and short flexors of great and little toes, and are thin, except along lateral border of foot, where a strong band extends from lateral process of tuber calcanei to base of 5th metatarsal. This band is a remnant of extensor ossis metacarpi digiti quinti.

Intermediate part, covering flexor dig. brevis, is very strong, and assists in preserving arch of foot. It is triangular in shape. **Apex** is attached to medial process of tuber calcanei (internal tubercle of calcis). **Base** divides into 5 slips (cf. palm, in which it divides into 4).

connected with each other by *transverse fibres*. A few superficial fibres of each slip run on to skin of creases of toes; main part divides into two bands which diverge and pass upwards to be attached to transverse metatarsal lig., and their anterior edges are continuous with proximal ends of fibrous flexor sheaths.

Deep fascia on toes is thickened to form **fibrous flexor** or **digital sheaths**. They are attached to margins of 1st phalanx in great toe, and 1st and 2nd of other toes, and to margins of plantar accessory ligaments. Together with phalanges and ligaments they form tunnels occupied by flexor tendons and their mucous or synovial sheaths. They are firm and dense opposite phalanges, weak opposite joints, so that movements of joints are not interfered with.

Plantar accessory ligaments and transverse metatarsal lig., mentioned above, are connected with joints. **Plantar accessory lig.**, a dense fibrous plate, is attached firmly to plantar surface of base of 1st phalanx, loosely to metatarsal, proximal to its head. Its *dorsal surface* is in contact with head of metatarsal, and forms part of its socket. Its *plantar surface* is covered by flexor tendons. Its *margins* are connected with fibrous flexor sheath, with slips of plantar aponeurosis, with collateral ligs. of joint, and with transverse metatarsal lig. Interphalangeal joints have similar plantar accessory ligaments. *Transverse metatarsal lig.* consists of 4 flat bands (cf. hand, in which there are only 3 bands) connecting the margins of plantar accessory ligaments of metatarso-phalangeal joints. Digital vessels and nerves, and lumbricals, lie on their *plantar* aspects, interosseous muscles on their *dorsal* surfaces.

As the tendons of flex. dig. longus, flex. hall. longus and tibialis posterior, and the post. tibial vessels, and tibial nerve pass from leg towards sole, they are bound down by a thickening of deep fascia of leg, called **lig. laciniatum** (int. annular). It extends from medial malleolus to medial process of tuber calcanei (int. tubercle of os calcis). Its proximal edge is continuous with fascia covering deep muscles of back of leg, and to a less extent with fascia covering superficial muscles. Its distal edge is continuous with medial part of plantar aponeurosis and gives origin to abductor hallucis. It is pierced, near calcanean attachment, by medial calcanean vessels and nerves. Under cover of it lie tibialis posterior, flex. dig. longus, post. tibial artery and venæ comites, tibial nerve, flex. hallucis longus, in that order from medial to lateral side, each tendon having a separate mucous (synovial) sheath.

First Layer of Muscles of Sole of Foot.—Abductor hallucis, flexor digitorum brevis, abductor digiti quinti.

Abductor hallucis covers long tendons as they enter sole, and lies along medial side of sole. It **arises** by tendinous and fleshy fibres from medial process of tuber calcanei, lig. laciniatum (int. annular), investing fascia, and septum between it and flexor dig. brevis; and is **inserted** by tendon into tibial side of base of 1st phalanx of hallux.

It abducts and flexes great toe. *Medial plantar nerve* supplies it by fibres derived from 5th lumbar and 1st sacral nerves.

Flexor digitorum brevis arises by fleshy and tendinous fibres from medial process of tuber calcanei and septa and fascia surrounding it, divides into 4 tendons for lateral 4 toes. Each tendon enters fibrous flexor sheath opposite head of metatarsal, on plantar aspect of long flexor tendon; splits opposite 1st phalanx to allow long flexor to pass through it; the halves reunite on dorsal aspect of long flexor, and, after partial decussation, separate to be **inserted** into sides of 2nd phalanx. It flexes 2nd and 1st phalanges. *Medial plantar nerve* supplies it by fibres from L. 5, S. 1.

Abductor digiti quinti arises by fleshy and tendinous fibres from medial process of tuber calcanei, under cover of flex. dig. brevis; from lateral process, from fascia covering it and septum on medial side; and is **inserted** into lateral side of base of 1st phalanx of little toe, and often also into base of 5th metatarsal. It abducts and flexes little toe. *Lateral plantar nerve* supplies it by fibres from S. 1, 2.

Second Layer of Muscles of Sole of Foot—Flexor hallucis longus, flexor digitorum longus with quadratus plantæ, and four lumbricals.

Flexor digitorum longus tendon, after entering sole, crosses superficial to tendon of hallucis, and obtains a slip from it, which usually passes into tendons for 2nd and 3rd toes; receives insertion of quadratus plantæ; divides into 4 tendons for lateral 4 toes. Tendons give origin to lumbrical muscles, and each enters fibrous flexor sheath, enclosed with corresponding tendon of flexor brevis in a mucous sheath; perforates that tendon opposite 1st phalanx, and runs on to **insertion** into plantar surface of base of 3rd phalanx.

Superficial to it, in succession from proximal side of ankle joint to fibrous flexor sheath, are (1) lig. laciniatum (int. annular), (2) abductor hallucis, (3) medial plantar vessels and nerves, (4) flexor digitorum brevis. *Deep to it* are (1) tibia posterior, (2) ankle joint, (3) edge of sustentaculum tali, (4) flexor hallucis longus, (5) sheath of peroneus longus, (6) adductor hallucis.

Quadratus plantæ (accessorius) lies deep to posterior part of flex. dig. brevis. It **arises** (1) from long plantar lig., part of which it covers, and also by (2) a tendinous head from lateral edge of plantar surface of calcaneus, anterior to lateral process, (3) a fleshy head from concave medial surface of calcaneus. It is **inserted** into tendon of flex. dig. longus. It changes oblique direction of the pull of that tendon into one in line with long axis of foot, and, by contracting independently, it can flex terminal phalanges without the stability of ankle-joint being impaired, e.g. walking over a slippery surface. *Lateral plantar nerve* supplies it by fibres from S. 1, 2.

Lumbrical muscles are 4 slender muscular bellies, smaller than those of hand. Their tendons pass dorsally and distally on tibial sides of metatarso-phalangeal joints of the lateral 4 toes, and each is

inserted into extensor tendon, base of 1st phalanx, and capsule of joint; each flexes 1st phalanx, since it passes from plantar to dorsal aspect over the joint, and extends 2nd and 3rd phalanges, since it is inserted into extensor tendon. **First** arises from tibial side of tendon of long flexor to 2nd toe, and is supplied by 2nd digital branch of *medial plantar nerve* (fibres ultimately from L. 5, S. 1). **Second, third and fourth** arise from contiguous sides of the 4 tendons of flexor longus, and are supplied on their dorsal surfaces by deep branch of *lateral plantar nerve* (fibres ultimately from S. 1, 2).

Flexor hallucis longus tendon, after entering sole, is crossed superficially by flexor dig. longus, and gives it a slip which goes usually into tendons for 2nd and 3rd toes. It is inserted into plantar surface of base of 2nd phalanx of great toe.

Superficial to it, from proximal side of ankle-joint to flexor fibrous sheath, are (1) lig. laciniatum (int. annular) and (2) lateral plantar vessels and nerve; (3) abd. hallucis, (4) medial plantar vessels and nerve, and (5) flex. dig. longus; (6) flex. dig. brevis, overlapping; (7) plantar aponeurosis. *Deep to it* are (1) distal end of tibia, (2) ankle-joint, (3) posterior surface of talus (astragalus), (4) plantar surface of sustentaculum tali, (5) lateral part of plantar calcaneo-navicular lig. (spring lig.), (6) plantar surface of navicular bone and ligaments attached to it, (7) flexor hallucis brevis. [It grooves (1), (3), and (4).]

Separate **mucous or synovial sheaths** surrounding tendons of flexor dig. longus and hall. longus extend from about 1 inch proximal to lig. laciniatum (int. annular) as far as middle of sole. Near the heads of metatarsals the tendons acquire new sheaths, which surround them to their insertions and line the fibrous flexor sheaths. Between phalanges and tendons at their insertion the mucous sheaths are pinched up to form triangular folds called *vincula brevia*. At more proximal levels fibrous cords with mucous covering pass between phalanges and tendons. These are called *vincula longa*. Blood-vessels run in *vincula* to the tendons.

Third Layer of Muscles of Sole of Foot.—Flexor hallucis brevis, adductor hallucis, flexor digiti quinti brevis.

Flexor hallucis brevis lies along plantar surface of 1st metatarsal. It arises by tendon from medial part of plantar surface of cuboid and from slips of tendon of tibialis posterior to 3rd and 2nd cuneiforms. It divides into two parts, the *medial* of which is inserted, in company with abductor, into medial side of base of 1st phalanx of hallux, while *lateral part* is inserted, together with adductor, into lateral side of the same. Sesamoid bones are developed in the tendons of insertion; these replace the plantar accessory ligament, and articulate with and groove the plantar surface of head of 1st metatarsal. It flexes great toe. First digital branch of *medial plantar nerve* supplies it by fibres from L. 5, S. 1.

Adductor hallucis arises by two heads, which are inserted together, by tendon, into lateral side of base of 1st phalanx. *Oblique*

head arises by fleshy and tendinous fibres from fibrous sheath of peronæus longus and plantar surface of bases of 2nd, 3rd, 4th metatarsals; it adducts and flexes great toe. *Transverse head arises* by fleshy fibres from 4 lateral plantar accessory ligaments at their metatarsal attachments, and from plantar surface of transverse metatarsal lig.; it draws all the toes together. Deep branch of *lateral plantar nerve* supplies both heads by fibres from s. 1, 2.

Flexor digiti quinti brevis lies along plantar surface of 5th metatarsal. It **arises** by fleshy and tendinous fibres from fibrous sheath of peronæus longus and from plantar surface of base of 5th metatarsal; and is **inserted** by tendon into lateral side of base of 1st phalanx of little toe, along with abductor. Superficial branch of *lateral plantar nerve* supplies it by fibres from s. 1, 2.

Medial plantar nerve, the larger terminal branch of tibial, arises under cover of lig. laciniatum (int. annular); proceeds forwards under cover of abductor hallucis, and then between it and flexor dig. brevis, under cover of deep fascia. It lies on plantar aspect of quadratus plantæ (accessorius), tendons of long flexors and flexor hallucis brevis, and divides into 4 digital branches. **First** supplies medial side of foot and great toe; **second** supplies sides of 1st cleft; **third** and **fourth** run, superficial to flexor dig. brevis tendons, to 2nd and 3rd clefts. Small branches are given to skin of medial part of sole. It supplies 4 muscles: abductor hallucis and flexor dig. brevis from its trunk; flex. hall. brevis from 1st digital branch; first lumbrical from 2nd digital branch. It corresponds to median nerve in palm.

Medial plantar artery, the smaller terminal branch of posterior tibial, begins under cover of lig. laciniatum or at its distal border; accompanies medial plantar nerve, ends by joining plantar digital artery to medial side of hallux; gives off muscular and cutaneous branches, and may give branches to accompany some or all of the digital branches of the nerve. It is accompanied by *venæ comites*.

Lateral plantar artery begins at same point as medial, runs laterally and distally to interval between flexor digiti quinti brevis and abductor dig. quinti, and at base of 5th metatarsal it turns medially across sole to base of 1st metatarsal as *plantar arch*.

Branches.—Muscular, cutaneous, and *medial calcanean*, which pierce lig. laciniatum or abductor hallucis to reach sole of heel.

Relations.—It is accompanied by *venæ comites* and lateral plantar nerve, which lies on its medial or concave side. *On its plantar aspect* are abductor hallucis, flexor digitorum brevis, deep fascia. *On its deep aspect* are flexor hall. longus, quadratus plantæ and long plantar ligament; and the peronæus longus tendon and flex. dig. quinti brevis, in interval between flex. dig. brevis and abductor dig. quinti.

Plantar arch is the continuation of lateral plantar artery and is completed medially by dorsalis pedis, at *proximal*, i.e. *posterior*, end of 1st intermetatarsal space. It is accompanied by *venæ comites* and deep branch of lateral plantar nerve. *Deep*, i.e. *dorsal*, to it are

bases of 2nd, 3rd, 4th metatarsals and proximal ends of interosseous muscles. *On its plantar side* are the oblique head of adductor hallucis, and flexor dig. longus, lumbricals, and, superficial to these, the flexor dig. brevis.

Branches.—(1) **Articular** to tarsal joints. (2) *Plantar digital artery* to fibular side of little toe. (3) The **posterior perforating**, which pass dorsally through proximal parts of lateral 3 intermetatarsal spaces to join dorsal metatarsal arteries. (4) Three **plantar metatarsal arteries** run distally on plantar aspects of interossei, and dorsal to transverse head of adductor, to the clefts between 4 lateral toes, and divide into *plantar digital arteries* for the sides of the clefts. Each metatarsal artery sends an *anterior perforating artery* dorsally to join a dorsal metatarsal; and the medial two plantar metatarsal arteries may be joined by digital branches of medial plantar. On the digits the arteries lie dorsal to the nerves and supply plantar surfaces and sides, form plexuses and arches in pulp of toes, anastomose with dorsal digitals, and supply dorsal aspects of 2nd and 3rd phalanges.

Dorsalis pedis artery dips down into sole through proximal end of 1st intermetatarsal space, joins plantar arch, and at point of junction gives off **first plantar metatarsal artery**, which runs to 1st cleft and divides into *plantar digital arteries* for both sides of great toe and medial side of second.

Lateral plantar nerve, the smaller terminal branch of tibial, arises under cover of lig. laciniatum (int. annular); accompanies lateral plantar artery, and has the same relations. Its trunk supplies quadratus plantæ and abductor dig. quinti and skin of sole; and at base of 5th metatarsal it divides into superficial and deep branches. **Superficial branch** divides into two branches, of which the *medial* supplies skin of 4th cleft and communicates with branch of medial plantar to 3rd cleft, while the *lateral* supplies flexor dig. quinti brevis, 3rd plantar and 4th dorsal interosseous, skin of sole and of lateral side of little toe. **Deep branch** accompanies plantar arch on its concave or posterior aspect; ends in oblique head of adductor hallucis; sends *branches* to remaining interossei, to transverse head of adductor, and to 2nd, 3rd, and 4th lumbricals, the branch to 2nd lumbrical passing dorsal to transverse head and turning downwards and backwards to lumbrical.

Fourth Layer of Muscles.—Interossei and tendons of tibialis posterior and peroneus longus.

Interosseous muscles are 7 in number, 3 plantar and 4 dorsal. Their tendons pass dorsal to transverse metatarsal lig., and each is **inserted** into base of 1st phalanx, capsule of metatarso-phalangeal joint, and very slightly into extensor tendon of toe upon which it acts (cf. lumbricals). Dorsal interossei lie between metatarsals and are seen on dorsum of foot as well as in sole. *Lateral plantar nerve* supplies them all by fibres derived from s. 1, 2: the 3rd plantar and 4th dorsal through its superficial branch, the rest through its deep branch.

Plantar interossei arise from plantar aspects of 3rd, 4th, 5th

metatarsals, and are inserted on tibial sides of 3rd, 4th, 5th toes. They flex 1st phalanges, extend 2nd and 3rd slightly (cf. lumbricals), and adduct these toes towards second toe.

Dorsal interossei arise from adjacent sides of metatarsals between which they lie. The first is inserted into tibial side of 2nd toe, the second, third, and fourth into fibular sides of 2nd, 3rd, and 4th toes. They flex 1st phalanges, and extend 2nd and 3rd phalanges slightly. Third and fourth abduct 3rd and 4th toes from 2nd. First and second alternately abduct and adduct 2nd toe, *i.e.* the first abducts it towards hallux, second adducts it to former position, and, continuing to act, abducts it towards 3rd toe, and it is adducted to former position by the first.

Each toe, therefore, has its abductor and adductor. Hallux has its special abductor and adductor; 2nd, 3rd and 4th toes have each two interossei, and 5th toe has its special abductor and the third plantar interosseous as adductor.

Tibialis posterior tendon, as it passes to insertion is *under cover* of lig. laciniatum and cutaneous vessels; and flex. dig. longus is superficial to it, proximal to ankle joint. *Deep to it* are posterior surface of medial malleolus, deltoid lig. just above sustentaculum tali, plantar calcaneo-navicular lig., which separates it from head of talus (astragalus). A sesamoid fibro-cartilage or bone is developed in it as it crosses the calcaneo-navicular lig. It is inserted chiefly into tubercle of navicular and 1st cuneiform; by small slips also into plantar surfaces of sustentaculum tali, 2nd and 3rd cuneiforms, groove on cuboid (*i.e.* all tarsals except talus), and into bases of 2nd, 3rd, and 4th metatarsals. A mucous sheath surrounds it from its insertion to an inch proximal to lig. laciniatum (int. annular).

As peroneal tendons lie on posterior surface of lateral malleolus, brevis is next the bone, and both are enclosed in a single *retinaculum* of deep fascia. When they leave malleolus and cross calcaneo-fibular ligament (middle band of ext. lateral), to lie on lateral surface of calcaneus (os calcis), brevis is above longus, and the retinaculum has divided to enclose them in separate compartments. Peroneus brevis runs on to insertion into base of 5th metatarsal.

Peronæus longus turns round lateral side of cuboid, passes medially and distally in groove on its plantar surface, and below the 3rd and 2nd cuneiforms, crossing slips from tibialis posterior; and is inserted into lateral side of base of 1st metatarsal and 1st cuneiform, near the sole (cf. tibialis anterior). A sesamoid bone, developed in the tendon as it enters sole, plays on a facet on cuboid. As the tendon lies in groove of cuboid the long plantar ligament, crossing it, holds it in place and forms its fibrous "sheath." Oblique head of adductor pollicis and the flex. dig. quinti brevis arise from the sheath.

Mucous sheath of peronæi, at first single, becomes double on lateral surface of calcaneus, and may follow both to their insertions, or that of longus may be interrupted at cuboid and start afresh.

Dorsum of Foot

Superficial fascia contains cutaneous nerves and superficial vessels, including *dorsal venous arch*, which lies across distal parts of metatarsals.

Superficial peroneal nerve (musculo-cutaneous) pierces deep fascia in distal third of leg as two branches, both of which supply skin of dorsum of foot. The *medial branch* ends in branches to distal part of medial side of foot and medial side of hallux, to contiguous sides of 2nd and 3rd toes, and to assist in supplying contiguous sides of great toe and 2nd. *Lateral branch* ends by supplying 3rd and 4th clefts. *Medial terminal branch* of **deep peroneal** (ant. tibial) gives the main supply to 1st cleft, and **nervus suralis** (short saphenous) supplies lateral side of little toe.

Deep fascia is thin except at ankle, where it is thickened to form lig. cruciatum.

Ligamentum cruciatum cruris (lower band of ant. annular) is occasionally X-shaped, but is usually Y-shaped. The *stem* of the Y is attached to anterior part of dorsal surface of calcaneus, and extensor digitorum brevis arises from it. *Proximal limb* is attached to medial malleolus, and *distal limb* is lost in the fascia on medial border of foot. It is well defined, but its proximal and distal borders are continuous with neighbouring deep fascia. *Under cover of it*, from medial to lateral side, lie (1) tibialis anterior, (2) ext. hallucis longus, (3) dorsalis pedis art. and deep peroneal nerve (ant. tibial), (4) extensor digitorum longus and peronæus brevis. These structures occupy four compartments, those for the tendons being lined with mucous (synovial) sheaths, which begin about an inch proximal to lig. cruciatum and extend around tibialis and peronæus tertius to their insertions, and around the extensors to about middle of foot.

Tibialis anterior tendon, easily felt and seen, passes distally and medially across ankle-joint, talus (astragalus), navicular, and 1st cuneiform, to be inserted into impression on medial surface of 1st cuneiform, near the sole, and into adjoining part of base of 1st metatarsal (cf. peronæus longus).

Extensor hallucis longus tendon runs distally on lateral side of tibialis anterior and medial side of dorsalis pedis artery, and then over metatarsal and 1st phalanx of great toe, to be inserted into dorsum of base of 2nd phalanx.

Extensor digitorum longus tendon crosses ankle-joint and divides beneath lig. cruciatum (ant. annular) into 4 tendons. These diverge and run to the lateral 4 toes, superficial to extensor brevis. On the first phalanx each is joined by fibres from interossei and a lumbrical, and, except in the case of little toe, by a tendon of extensor brevis; and it spreads out to form the **dorsal extensor expansion**, which divides into three parts at distal end of 1st phalanx. The *middle piece* is in-

inserted into dorsum of base of middle phalanx; the two *lateral* pieces run on, join each other, and are **inserted** into dorsum of base of 3rd phalanx. The tendons replace the fibrous stratum of capsule on the dorsum of the metatarso-phalangeal and interphalangeal joints.

Peronæus tertius arises in common with ext. dig. longus, but distal to it. Its tendon separates at ankle-joint, but is contained in same compartment of lig. cruciatum. It passes superficial to extensor brevis to be **inserted** into dorsum of base of 5th metatarsal.

Extensor digitorum brevis arises by fleshy fibres from anterior part of dorsal surface of calcaneus (os calcis) and from deep surface and distal border of stem of lig. cruciatum (lower band of ant. annular). It divides into 4 fleshy bellies, which extend obliquely, distally and medially, across tarsus and metatarsus, beneath the tendons of longus, and end in 4 tendons for the medial 4 toes. Tendon to great toe (ext. hallucis brevis) crosses 1st dorsal metatarsal art. or dorsalis pedis as it dips towards sole, and is **inserted** independently into dorsum of base of 1st phalanx of hallux. Other three tendons join dorsal expansions of tendons of longus. *Lateral branch of deep peroneal nerve* (ant. tibial supplies it, by three from 1, 4, 5, 8, 1).

Dorsalis pedis artery begins on anterior aspect of ankle joint, midway between malleoli, as a continuation of anterior tibial. It runs distally to **proximal end** of 1st intermetatarsal space, where it dips down into sole, and ends by joining plantar arch.

Relations —Vene comites accompany it. It lies on talus (astragalus), navicular and 2nd cuneiform. Lig. cruciatum crosses its proximal part; medial tendon of ext. dig. brevis often crosses it where it dips towards sole. Ext. hall. longus lies above its medial side. Medial branch of deep peroneal nerve (ant. tibial) runs along its lateral side; and a little more laterally are the ext. dig. longus and brevis.

Branches of Dorsalis Pedis. Cutaneous, lateral tarsal, arcuate (metatarsal), first dorsal metatarsal (interosseous), and, in the sole, the 1st plantar metatarsal art. magna hallucis.

Lateral tarsal artery arises opposite talus or navicular, runs laterally beneath ext. brevis, and anastomoses with peroneal artery and its perforating branch, and lateral malleolar artery, around and below lateral malleolus.

Arcuate artery (metatarsal) runs laterally, over dorsum of bases of metatarsals, beneath ext. brevis; gives a branch to fibular side of little toe and three **dorsal metatarsal arteries** (interosseous). These run distally, on interosseous muscles, in the lateral three spaces; are joined by posterior and anterior perforating arteries from plantar arch and plantar metatarsals, respectively, and each divides at the cleft of the toes into two *dorsal digital arteries*, which ramify over 1st phalanges.

First dorsal metatarsal artery (interosseous) arises at proximal end of 1st space; runs distally on 1st dorsal interosseous muscle, and divides into *dorsal digital branches* for sides of great toe and medial side of second toe.

Deep peroneal nerve (anterior tibial) enters foot on lateral side of dorsalis pedis, and divides into medial and lateral branches. **Medial branch** runs along lateral side of dorsalis pedis, giving branches to joints; accompanies 1st dorsal metatarsal artery, giving a branch to 1st dorsal interosseous muscle (said to be sensory); pierces deep fascia and supplies contiguous sides of great and second toes. **Lateral branch** turns laterally, and ends under ext. dig. brevis, by giving branches to it, to joints, and a branch (said to be sensory) to 2nd dorsal interosseous muscle.

CLASSIFICATION OF MUSCLES OF LOWER LIMB

As in the upper limb, the muscles of the lower limb have been classified according to regions. The following grouping is based on their attachments and the joints upon which they act.

Note that the shoulder girdle is movable and the pelvic girdle is rigid. All the muscles connecting shoulder girdle to axial skeleton, except sterno-cleido-mastoid, sterno-hyoid, and omio-hyoid, act primarily on the girdle, but may act on the axial skeleton if the shoulder girdle is fixed. The muscles passing between pelvic girdle and trunk—sacrospinalis, quadratus lumborum, psoas minor, transversus and obliquus externus and internus abdominis, rectus abdominis, coccygeus, (levator ani)—act on the trunk, but may, in the unusual circumstance of the upper part of the trunk being more fixed than the lower, move the pelvic girdle, together with the lower part of the vertebral column, at the movable joints of the vertebral column.

Muscle extending from **vertebral column to femur**, acting on *vertebral joints and hip-joint*. Psoas major.

Muscles extending from **vertebral column and pelvic girdle to femur**, acting on *hip-joint*. Gluteus maximus, piriformis.

From **pelvic girdle to femur**, acting on *hip-joint*. Gluteus medius and minimus, obturator externus and internus, and gemelli, quadratus femoris, iliacus (attached also to sacrum), pectineus, adductor longus, brevis and magnus.

From **pelvic girdle to tibia**, acting on *hip and knee joints*. Sartorius, gracilis, semitendinosus, semimembranosus, rectus femoris.

From **pelvic girdle and femur to fibula**, acting on *hip and knee joints* (and tibio-fibular joint). Biceps.

From **femur to tibia**, acting on *knee-joint*. Vastus lateralis, medialis and intermedius (crureus), and popliteus.

From **femur to tarsus**, acting on *knee and ankle joints*. Gastrocnemius, plantaris.

From **bones of leg to tarsus**, acting on *ankle-joint*. Soleus.

From **bones of leg to tarsus and metatarsus**, acting on *tarso-metatarsal, intertarsal and ankle joints*. Tibialis anterior and posterior, and peronæus longus.

From **bones of leg to metatarsus**, acting on *tarso-metatarsal, intertarsal and ankle joints*. Peronæus brevis and tertius.

From **bones of leg to phalanges**, acting on *interphalangeal, metatarso-phalangeal* (also *metatarsal, intertarsal and ankle joints*). Ext. hallucis and digitorum longus, flex. hall. and ing. longus.

From **tarsus to phalanges**, I. acting on *metatarso-phalangeal, tarso-metatarsal* (and *intertarsal joints*), abductor hallucis and digiti quinti, flexor hallucis brevis. II. Acting also on *interphalangeal joint*. Ext. dig. brevis, flexor dig. brevis, quadratus plantæ.

From **metatarsus to phalanges**, acting on *metatarso-phalangeal joints*. Flexor dig. quinti brevis, adductor hallucis; seven interossei (act on interphalangeal also).

FASCLE OF DORSAL ASPECT OF TRUNK

The **superficial fascia** of the back contains cutaneous nerves and vessels. In the upper part of the trunk the nerves are the *medial divisions* of the **posterior branches** (posterior primary divisions) of thoracic nerves; in the lower part they are the *lateral divisions*, and therefore appear farther away from median plane. Of the lumbar posterior branches only the lateral divisions of the upper three appear on the surface, and they descend into buttock. The nerves are accompanied by branches of posterior divisions of intercostal and lumbar vessels.

Deep fascia of the back is attached *superiorly* to superior nuchal (curved line of occipital; *at median plane* to ligamentum nuchæ and spines of vertebrae. *Laterally* it is continuous with deep cervical fascia in neck; at shoulder it is connected with spine of scapula and clavicle, and continued into fascia over deltoid; below shoulder it is continuous with fascia of axilla and abdominal wall. *Inferiorly* it blends with lumbar part of lumbo-dorsal fascia.

Fascia lumbo-dorsalis consists of three laminae. (1) **Vertebral aponeurosis**, or aponeurosis of latissimus dorsi, is attached below to crest of ilium, extends upwards, covering sacrospinalis muscle, being attached to spines of vertebrae and angles of ribs. (2) **Middle layer** lies between sacrospinalis and quadratus lumborum. Attached medially to tips of lumbar transverse processes, superiorly to last rib, inferiorly to iliac crest. (3) **Anterior layer** lies on abdominal surface of quadratus lumborum. Attached medially to anterior surfaces of lumbar transverse processes near bases; superiorly to last rib, and there it gives partial origin to diaphragm; inferiorly to crest of ilium, and it is thickened to form ilio-lumbar ligament. The three layers meet at lateral border of quadratus to form a strong band, from which obliquus internus and transversus abdominis obtain partial origin.

In B.N.A. the anterior layer described here is not included in *lumbo-dorsal fascia*.

MUSCLES OF DORSAL ASPECT OF TRUNK

First Group.—Trapezius, latissimus dorsi. **Second Group.**—Levator scapulæ, rhomboidei : all considered under upper limb.

Third Group.—Serratus posterior superior, and serratus posterior inferior, splenius.

Serratus posterior superior lies between rhomboidei and vertebral aponeurosis. **Origin** (tend.): Lig. nuchæ, last cervical and upper 3 thoracic spines. **Insertion** (fl.-tend.): 2nd to 5th ribs, in front of angles. **Nerves**: Upper 3 or 4 intercostals. It elevates ribs; flexes vertebral column laterally.

Serratus posterior inferior lies under cover of latissimus dorsi. **Origin** (tend.): last 2 thoracic, first 2 lumbar spines. **Insertion** (fl.): lower 4 ribs, in front of angles. **Nerves**: 9th, 10th, 11th intercostals. It depresses and draws lower ribs backwards.

Splenius.—Lies in back of neck and of upper part of trunk, partly under cover of sterno-mastoid, trapezius, levator scapulæ, rhomboidei; partly superficial in floor of posterior triangle of neck. **Origin** (tend.): lower $\frac{1}{2}$ of lig. nuchæ, last cervical and upper 5 thoracic spines and supra-spinous ligaments. **Insertion** (tend.): *splenius capitis* into mastoid process and lateral $\frac{1}{2}$ of superior nuchal line; *splenius cervicis* into posterior tubercles of transverse processes of upper 2 to 4 cervical vertebræ. **Nerves**: lateral divisions of post. branches of 4th to 8th cervical nerves. Muscles of both sides acting extend head and neck; one muscle acting bends head and neck to that side and turns face towards that side.

Fourth Group.—Sacrospinalis, semispinalis capitis.

Sacrospinalis (Erector Spinæ).—Lies on dorsum of sacrum and in small of back. **Arises** from iliac crest (fl.-tend.), post. sacro-iliac ligament, dorsal surface of sacrum, spines of upper sacral and all lumbar vertebræ. Divides into 3 columns, which lie in groove between thoracic spines and angles of ribs, and in back of neck: (1) iliocostalis, laterally; (2) longissimus, intermediate; (3) spinalis, medially. They are attached by tendinous slips.

(1) **Iliocostalis Lumborum** is inserted into lower 6 ribs. **Iliocostalis Dorsi** (accessorius) arises from lower 6 ribs, medial to iliocostalis lumborum; inserted into upper 6 ribs. **Iliocostalis Cervicis** (cervicalis ascendens) arises from upper 6 ribs, medial to iliocostalis dorsi; inserted into post. tubercles of 4th, 5th, 6th cervical transverse processes.

(2) **Longissimus Dorsi** is inserted into transverse and accessory processes of lumbar vertebræ, all thoracic transverse processes, lower 10 ribs. **Longissimus Cervicis** (transversalis cervicis) arises from upper 6 thoracic transverse processes, medial to L. dorsi; inserted into post. tubercles of 2nd to 6th cervical transverse processes.

Longissimus Capitis (trachelo-mastoid) lies in back of neck and of upper part of trunk, between splenius and semispinalis capitis (complexus). **Arises** from upper 6 thoracic transverse processes, in company with L. cervicis, and from articular processes of lower 4 cervical vertebræ. **Inserted** into mastoid process, under cover of splenius. Both muscles acting extend head; one acting alone bends head to that side, and turns face towards that side.

(3) **Spinalis Dorsi** arises from upper 2 lumbar and lower 2 thoracic spines (tend.), and tendon of longissimus dorsi (fl.); inserted into upper 4 to 8 thoracic spines.

Spinalis Cervicis. Inconstant. **Arises** from upper 2 thoracic and last cervical spine, inserted into 2nd, 3rd, 4th cervical spines.

Semispinalis Capitis (Complexus).—Lies in back of neck and upper part of trunk, under cover of trapezius and splenius. **Arises** from upper 6 thoracic transverse processes, and articular processes of lower 4 cervical vertebræ (cf. longissimus capitis); inserted into oval impression on occipital bone, between superior and inferior nuchal lines, close to median plane (fl.). Both muscles acting extend head; one acting alone bends head to that side, and turns face to opposite side.

Fifth Group Semispinalis dorsi, semispinalis cervicis, multifidus.

Semispinalis Dorsi lies under cover of spinalis, arises from lower 6 thoracic transverse processes (tend.), inserted into upper 4 thoracic and lower 2 cervical spines (tend.).

Semispinalis Cervicis lies under cover of semispinalis capitis. **Arises** from upper 6 thoracic transverse processes, and articular processes of lower 4 cervical vertebræ (tend.) (cf. semispinalis and longissimus capitis), inserted chiefly into 2nd cervical spine, but also into 3rd, 4th, 5th (fl.-tend.)

Multifidus lies on laminae, deep to sacrospinalis and semispinalis, arises from dorsal surface of sacrum, post. sacro-iliac ligament, lumbar mamillary processes, thoracic transverse processes, articular processes of lower 4 cervical vertebræ (fl.-tend.); inserted into spines, up to and including that of 2nd cervical.

Sixth Group—Rotatores, interspinales, intertransversales, obliquus capitis sup. and inf., rectus capitis posterior major and minor.

Rotatores.—Eleven on each side, deep to multifidus. Each

arises from a thoracic transverse process and is inserted into lamina immediately above (fl.-tend.). **Interspinales** connect spinous processes. **Intertransversales** connect transverse processes. Seven pairs on each side in *cervical* region, connected with anterior and posterior tubercles; an anterior branch of cervical nerve passes out between each pair; rectus capitis lateralis (p. 203) is homologous with posterior intertransverse. Ill-developed in *thoracic* region. Arranged in pairs in *lumbar* region, the **lateral** connecting the transverse processes, **medial** connecting mamillary process of one vertebra with accessory process of vertebra above.

Remaining muscles of sixth group lie in upper part of back of neck, under cover of splenius and semispinalis capitis (complexus). They are supplied by the posterior branch of 1st cervical nerve:—

Obliquus Capitis Inferior.—**Origin** (tend.-fl.): 2nd cervical spine; **insertion** (fl.-tend.): transverse process of atlas. It turns face to same side.

Obliquus Capitis Superior.—**Origin** (fl.-tend.): transverse process of atlas; **insertion** (fl.): lateral part of space between nuchal lines of occipital bone. Bends head backwards and to same side; turns face to opposite side.

Rectus Capitis Posterior Major.—**Origin** (tend.): 2nd cervical spine; **insertion** (fl.): lateral part of space below inf. nuchal line. Both acting extend head. One acting alone turns face to same side.

Rectus Capitis Posterior Minor lies medial to and partly under cover of major. **Origin** (tend.): Tubercle on post. arch of atlas; **insertion** (fl.): medial part of space below inf. nuchal line. Extends head.

Sub-occipital Triangle.—Placed deeply at upper part of back of neck. **Boundaries**: Obliquus inferior, infero-laterally; obliquus superior, supero-laterally; rectus major, supero-medially. **Roof**: Splenius capitis, laterally; semispinalis capitis (complexus), medially. Greater occipital n. crosses triangle, superficially, under cover of these. **Floor**: Posterior arch of atlas; and, when boundaries are separated, ligaments uniting arch to post. margin of foramen magnum and to 2nd cervical lamina. **Contents**: (1) Vertebral artery, in groove on posterior arch; (2) posterior branch of sub-occipital or 1st cervical nerve, emerging from below artery and dividing to supply adjacent muscles; (3) fatty and fibrous tissue and plexus of veins.

Nerve Supply of Muscles of Back.—Splenius and the muscles of 4th, 5th, and 6th groups are supplied by **posterior** branches of spinal nerves, mainly through *lateral* divisions in *upper* part of trunk, mainly by *medial* divisions in *lower* part.

Actions of Muscles of Back.—Those whose actions have

not been given above, raise the flexed trunk to the erect posture, maintain it there, and may bend it backwards. When muscles of one side act they bend trunk and head to that side; and those which run obliquely upwards and medially rotate them towards opposite side; those which run upwards and laterally (few in number) rotate towards same side.

FASCLE AND MUSCLES OF HEAD AND NECK

Superficial Fascia contains superficial vessels and nerves, and, in some situations, muscles—all detailed in their regions. *Over scalp*: very firm, fibrous and dense, closely adherent to skin and subjacent galea aponeurotica (epicranial aponeurosis), so that these three form one layer in a wound flap. *In eyelids*: loose, very thin and contains no fat. *In face*: facial muscles are imbedded in it; and it is continuous with a collection of fat, called **corpus adiposum buccæ** or **suctorial pad**, which lies between masseter and buccinator. *On side of neck*: platysma is imbedded in it. *Below chin*: fat tends to accumulate in it in stout persons.

Deep Fascia. *Over scalp*: very thin over muscular bellies of epicranus; fused with galea aponeurotica. *At side of head*: **temporal fascia**, very firm and strong, attached to boundaries of temporal fossa; attachment to zygomatic arch is by two layers, between which are some fat and zygomatico-orbital artery. *In face*: practically non-existent, except posteriorly, where **fascia parotideo-masseterica** covers masseter and parotid gland, and is connected with zygomatic arch above and fascia of neck below.

In the neck the deep fascia forms a continuous envelope attached *superiorly* to ext. occipital protuberance, superior nuchal line, mastoid temporal, body of mandible, and is prolonged upwards to ensheath parotid and submaxillary glands. A thickened part of parotid sheath, attached to styloid process and angle of mandible, is called **stylo-mandibular ligament**, and separates parotid from submaxillary gland. Deeper layer of parotid sheath is attached to tympanic plate; deep layer of submaxillary sheath is attached to mylo-hyoid line. Cervical fascia is split into two layers to enclose sterno-mastoid and trapezius. In front of and behind sterno-mastoid it forms roofs of ant. and post. triangles of neck. Two layers are fused over upper parts of triangles. Over lower part of post. triangle layers remain separate, are attached to upper and lower borders of posterior aspect of clavicle; enclose transverse scapular (supra-scapular) vessels, lower end of ext. jugular vein; and deeper layer is connected with fascia of omohyoid, and binds it down. Lower parts of the layers remain separate at median plane also; attached to front and back of upper end of manubrium; enclose sternal heads of sterno-mastoids, ant. jugular veins and anastomosis

between them, interclavicular ligament, fatty areolar tissue and sometimes a lymph gland.

At median plane in front, fasciæ of opposite sides are continuous, and are attached only to hyoid bone. At back of neck, fascia is attached to lig. nuchæ at median plane, and inferiorly is continuous with fascia of back medially, attached to spine of scapula laterally.

From its deep surface, especially from layer under sterno-mastoid, septa are sent in, from which secondary septa arise. These form sheaths for muscles, glands, pharynx, trachea, œsophagus, large vessels and nerves. Two of these are continuous with those of opposite side: (1) **Prevertebral fascia** covers longus colli and longus capitis (rect. cap. anticus major), and rectus capitis anterior (minor) and lateralis. It is continuous, *laterally* and *posteriorly* over scaleni, with fascia on floor of posterior triangle; attached *superiorly* to styloid process, jugular process and basilar portion of occipital; *inferiorly* it is continued down into thorax, in front of longus colli. (2) **Pretracheal fascia** extends across between deep surfaces of sterno-mastoids, in front of trachea, splitting to enclose thyroid gland and its capsule. *Above*, it is fixed to cricoid and thyroid cartilages. *Below*, it is continued downwards, in front of trachea, to be connected with pericardium.

Bucco-pharyngeal fascia covers constrictors of pharynx and buccinator. It is connected laterally with prevertebral fascia, but between these lateral attachments it is separated from prevertebral fascia by **retro-pharyngeal space** containing loose areolar tissue and some retro-pharyngeal lymph glands.

Carotid sheath is the fascia enclosing common and internal carotid arteries, int. jugular vein and vagus. It is connected with prevertebral and pretracheal fascia; sympathetic trunk is imbedded in posterior wall, descendens hypoglossi in ant. wall; descendens cervicalis n., cervical branches of vagus, tributaries of vein pierce it.

Fascia investing scalene muscles, subclavian vessels and brachial nerves, is carried down into axilla to form axillary sheath.

MUSCLES OF NECK

MUSCLES OF BACK OF NECK.—These are considered along with muscles of back.

MUSCLES OF SIDE OF NECK.—Platysma (see p. 232), sterno-mastoid.

Sterno-cleido-mastoideus (Sterno-mastoid).—Forms oblique elevation on side of neck, extending from manubrium to mastoid process, between triangles of neck. **Origin:** *Sternal head* (tend.): upper lateral part of anterior surface of manubrium sterni. *Clavicular head* (fl.-tend.): upper surface of medial $\frac{1}{3}$ of clavicle. **Insertion** (fl.-tend.): Outer

surface of mastoid process of temporal, lateral $\frac{1}{3}$ of sup. nuchal line of occipital. **Nerve** : (spinal) accessory and C. 2. Both muscles acting extend head or elevate anterior chest wall. One acting alone flexes head, bends it to that side and turns face towards opposite side.

Superficial surface is in relation to platysma ; ext. jugular vein, lesser occipital, great auricular, cutaneus colli, anterior supra-clavicular nerves ; lymph glands. Overlapped by parotid gland.

Deep surface is in relation to all three carotids, occipital, transverse scapular and cervical arteries ; int. and ant. jugular veins, (vagus), accessory, hypoglossal nerves, (sympathetic trunk), cervical plexus and its branches, including phrenic ; scaleni, levator scapulae, splenius, longus capitis, rectus cap. lateralis, post. belly of digastric, depressors of hyoid bone ; lymph glands. Accessory nerve pierces it.

MUSCLES OF HYOID BONE.—Omo-hyoid, sterno-hyoid, sterno-thyreoid with thyreo-hyoid, levator glandulae thyreoidae, digastric, stylo-hyoid, mylo-hyoid, genio-hyoid. Hyoglossus, middle constrictor, inf. longitudinal muscles of tongue, also attached to hyoid bone, are considered under other heads.

Omo-hyoideus.—*Posterior belly* arises from upper margin of scapula and its superior transverse lig. (fl.) ; passes forwards under trapezius to cross posterior triangle ; ends under cover of sterno-mastoid in *intermediate tendon*, which is bound down by fascia to back of clavicle and first rib, and gives rise to *anterior belly*, which ascends almost vertically to be inserted into lateral part of lower border of body of hyoid bone (fl.). **Nerve** : C. 1, 2, 3, through ansa hypoglossi. Depresses hyoid bone and draws it backwards and laterally.

Sterno-hyoideus lies in lower part of anterior triangle of neck. **Origin** (fl.) : posterior surfaces of manubrium and sternal end of clavicle. **Insertion** (fl.-tend.) : medial half of lower border of body of hyoid bone. **Nerve** : C. 1, 2, 3, through ansa hypoglossi. It depresses hyoid bone.

Sterno-thyreoides.—Lies in lower part of anterior triangle. **Origin** (fl.) : back of manubrium and 1st costal cartilage, below sterno-hyoid. **Insertion** (fl.) : oblique line of thyroid cartilage. **Nerve** : C. 1, 2, 3, through ansa hypoglossi. It depresses larynx.

Thyreo-hyoideus.—Continues direction of sterno-thyreoid ; lies deep to omo-hyoid, upon thyroid cartilage and thyreo-hyoid membrane. **Origin** (fl.) : oblique line of thyroid cartilage. **Insertion** (fl.-tend.) : lower border of body and

greater horn of hyoid. **Nerve**: c. 1, through special branch from hypoglossal. Depresses hyoid bone or elevates larynx.

Levator Glandulæ Thyreoideæ.—An occasional slip extending from pyramidal lobe of thyroid gland to hyoid bone.

Digastricus lies behind, deep to and below mandible. **Posterior belly**: **Origin** (fl.): mastoid notch under cover of mastoid process. **Insertion**: intermediate tendon. **Nerve**: facial. Draws hyoid bone with tongue upwards and backwards.

Superficial surface is in relation to platysma, sterno-mastoid, splenius, longissimus capitis, stylo-hyoid, parotid gland, pterygoideus internus and angle of mandible, submaxillary gland, ant. facial vein. **Deep surface** is related to stylo-glossus, stylo-pharyngeus, hyoglossus, middle constrictor; int. and ext. carotid and ext. maxillary arteries; int. jugular vein; glosso-pharyngeal, hypoglossal, accessory nerves. Occipital and post. auricular arteries run posteriorly along its lower and upper **borders**, respectively.

Anterior belly lies below chin on mylo-hyoid, under platysma, but may be felt subcutaneously. **Origin** (fl.): lower border of mandible, close to symphysis. **Insertion**: intermediate tendon. **Nerve**: trigeminal, through mylo-hyoid branch of inf. alveolar (inf. dental). Draws hyoid bone upwards and forwards; depresses mandible. **Intermediate tendon** is attached to body of hyoid bone by pulley-like band of fascia; it perforates stylo-hyoid and lies on hyoglossus.

Stylo-hyoideus lies behind and under cover of angle of mandible, applied to upper and anterior aspects of post. belly of digastric. **Origin** (fl.-tend.): styloid process near its base. **Insertion** (fl.-tend.): junction of body and great horn of hyoid bone, after perforation by intermediate tendon of digastric. **Nerve**: facial. Draws hyoid bone upwards and backwards.

Mylo-hyoideus forms, with its fellow, a diaphragm across floor of mouth (*v. p.* 222). **Origin** (fl.-tend.): mylo-hyoid line of mandible. **Insertion**: body of hyoid bone and median fibrous raphe, extending from hyoid bone to chin. **Nerve**: trigeminal, through mylo-hyoid branch of inf. alveolar (inf. dental). It elevates hyoid bone and tongue; depresses mandible.

Genio-hyoideus lies behind chin, between mylo-hyoid and genio-glossus, in apposition with its fellow. **Origin** (fl.-tend.): lower mental spine. **Insertion** (fl.): body of hyoid bone. **Nerve**: c. 1, through hypoglossal. Draws hyoid bone forwards and upwards; depresses mandible.

MUSCLES OF THE TONGUE

I. **Extrinsic**: genio-glossus, hyo-glossus, stylo-glossus, glosso-palatinus. II. **Intrinsic**: longitudinalis superior, longitudinales inferiores, transversus, verticalis.

Hypoglossal nerve supplies all muscles of tongue, except glosso-palatinus.

Genio-glossus.—Fan-shaped, apex at origin. In apposition with its fellow. Lateral surface in relation to mylo-hyoid, hyo-glossus, stylo-glossus, and sublingual gland. Genio-hyoid lies along lower border, mucous membrane of mouth on upper border. **Arises** from upper mental spine (fl.-tend.) and radiates into tongue from base to tip. Posterior or lower fibres protrude tongue; anterior retract. Whole of both muscles acting depress tongue and produce median longitudinal groove on it for passage of fluids.

Hyo-glossus lies below and internal to mandible, in front of its angle, superficial to genio-glossus, deep to mylo-hyoid, submaxillary gland, mucous membrane of mouth. **Origin** (fl.): body and greater horn of hyoid bone. **Insertion** (fl.): side of tongue, near base. Depresses tongue; elevates hyoid bone. *Chondro-glossus*, a small slip, not always present, extends from body and lesser horn of hyoid to side of tongue.

Stylo-glossus lies between mandible and side of tongue. **Origin** (fl.-tend.): styloid process near tip, stylo-hyoid ligament. **Insertion** (fl.): side of tongue from base to tip, interlacing with hyo-glossus posteriorly. Draws tongue upwards and backwards.

Glosso-palatinus (Palato-glossus) lies in glosso-palatine arch (ant. pillar of fauces), and forms lowest muscular stratum of velum palatinum (soft palate). **Origin** (fl.): lower surface of aponeurosis of velum palatinum, blending with muscle of opposite side. **Insertion** (fl.): side of tongue posteriorly, and mingles with transverse fibres of tongue. **Nerve**: (spinal) accessory, through pharyngeal plexus. Elevates tongue; constricts isthmus faucium.

Superior longitudinal muscle lies under mucous membrane of dorsum of tongue, and extends from tip to base. **Inferior longitudinal muscles** lie, one on each side, in lower part of tongue, deep to hyo-glossus and genio-glossus. Posterior fibres of each are connected with hyoid bone. The fibres of the **transverse muscle** extend from median raphe, through substance of tongue, to the sides and

dorsum. The fibres of the **vertical muscle** extend from dorsum, downwards and laterally, to the sides. These muscles alter the shape of tongue, and curve it in different directions.

MUSCLES OF PHARYNX

Superior, middle and inferior constrictors, stylo-pharyngeus, pharyngo-palatinus, salpingo-pharyngeus.

Constrictor Pharyngis Superior.—Arises from lower $\frac{1}{2}$ of posterior border of medial pterygoid lamina, pterygo-mandibular raphe, posterior end of mylo-hyoid line, mucous membrane of mouth and side of tongue (fl.). Fibres radiate to **insertion** in *median fibrous raphe* in posterior wall of pharynx, highest fibres reaching pharyngeal tubercle of occipital bone (fl.). **Nerve:** accessory, through pharyngeal plexus.

Constrictor Pharyngis Medius.—Fan-shaped. Arises from angle formed by greater horn of hyoid bone below, lesser horn and stylo-hyoid ligament above (fl.). Radiates to **insertion** into median raphe (fl.). **Nerve:** accessory, through pharyngeal plexus.

Constrictor Pharyngis Inferior.—Arises from oblique line and inf. cornu of thyreoid cartilage and side of cricoid cartilage (fl.), and radiates backwards and upwards to **insertion** into median raphe (fl.). **Nerve:** accessory, through pharyngeal plexus, external laryngeal and recurrent nerves.

Sup. constrictor is overlapped posteriorly and inferiorly by middle constrictor. Auditory (Eustachian) tube, tensor and levator veli palatini occupy interval (sinus of Morgagni) between its upper border and base of skull. Pterygoideus int. and stylo-pharyngeus are in relation to its external surface; pharyngo-palatinus to its internal surface.

Posteriorly the **middle constrictor** overlaps superior constrictor above, and is overlapped by inferior below. At the side, stylo-pharyngeus enters pharynx between it and sup. constrictor; and hyo-glossus, post. belly of digastric, stylo-hyoid are in relation to it.

Inf. constrictor overlaps middle constrictor superiorly; int. laryngeal vessels and nerve pierce thyreo-hyoid membrane, between their borders, under thyreo-hyoideus. Lower border is nearly horizontal, mingles with fibres of œsophagus, and inferior laryngeal vessels and nerve pass upwards under it. Sterno-thyreoid overlies it near origin.

Stylo-pharyngeus lies on outer surface of sup. constrictor above, between mucous membrane of pharynx and the two

other constrictors below. **Origin** (fl.-tend.) : styloid process near base. **Insertion** (fl.) : posterior border of thyroid cartilage ; side of pharynx, mingling with constrictors and pharyngo-palatinus. **Nerve** : glosso-pharyngeal. It elevates larynx and pharynx.

Pharyngo-palatinus (palato-pharyngeus) lies in pharyngo-palatine arch (post. pillar of fauces) ; in substance of soft palate ; and between mucous membrane and constrictors of pharynx. **Origin** (fl.) : in palate by two layers between which lie levator veli palatini and musculus uvulae. *Upper layer* is continuous with its fellow ; *lower layer* is attached to post. border of hard palate, and to palatine aponeurosis. **Insertion** (fl.) : post. border of thyroid cartilage ; wall of pharynx, mingling with constrictors. **Nerve** : accessory, through pharyngeal plexus. Elevates larynx and pharynx, constricts naso-pharyngeal isthmus.

Salpingo-pharyngeus arises from lower part of auditory (Eustachian) tube, runs down in salpingo-pharyngeal fold, and mingles with pharyngo-palatinus.

Pharyngeal Aponeurosis.—Lines inner surfaces of pharyngeal muscles, separates them from mucous membrane ; some of their fibres are inserted into it. It is thick above, especially opposite gap between base of skull and sup. constrictor, over whose upper border it is connected with bucco-pharyngeal fascia. It is attached above to basi-occiput and petrous temporal. Below, it becomes thin and is gradually lost, towards lower end of pharynx. It is thickened in median plane posteriorly to form a *median raphe*, extending from pharyngeal tubercle to lower end of pharynx. Upper thick part is called *pharyngo-basilar fascia*.

MUSCLES OF VELUM PALATINUM

Muscles of **soft palate** are : Glosso-palatinus and pharyngo-palatinus (*already described*) ; musculus uvulae, levator veli palatini, tensor veli palatini.

Musculus Uvulae (Azygos Uvulae).—Two small slips extending from post. nasal spine, unite into one and enter uvula. They lie between layers of pharyngo-palatinus. **Nerve** : accessory, through pharyngeal plexus (possibly facial, through post. palatine branch of sphenopalatine ganglion).

Levator Veli Palatini (Levator Palati).—**Origin** (fl.) : lower surface of petrous temporal near apex, medial surface of cartilage of auditory (Eustachian) tube. **Insertion** (fl.) : palatine

aponeurosis, many fibres also joining opposite muscle, between layers of pharyngo-palatinus. **Nerve**: accessory or facial, same as in. uvulae. It occupies interval above sup. constrictor, and crosses its upper border and pierces pharyngeal aponeurosis to enter palate.

Tensor Veli Palatini (Tensor Palati).—**Origin** (fl.-tend.): sphenoid bone from scaphoid fossa to angular spine, and from lateral surface of auditory tube. **Insertion** (tend.): palatine aponeurosis, and crest on lower surface of horizontal part of palatine bone, near posterior margin. **Nerve**: trigeminal, through otic ganglion.

Tensor lies *lateral to* auditory tube and pharyngeal aponeurosis, *medial to* pterygoideus int., mandibular division of trigeminal nerve, otic ganglion, mid. meningeal art. Rounded tendon turns round lower surface of hamulus pterygoideus (bursa intervening), at right angles to flat triangular fleshy belly, and enters palate.

Palatine aponeurosis lies in the substance of the soft palate and gives support to it. It is firm and strong anteriorly, where it is attached to post. edge of hard palate. Fades away postero-inferiorly. It is continuous with pharyngeal aponeurosis laterally.

Muscles of velum palatinum (soft palate) lie in the following order from dorsal to ventral surface: upper or posterior layer of pharyngo-palatinus, m. uvulae, levator, lower layer of pharyngo-palatinus, tensor and palatine aponeurosis, glosso-palatinus.

Muscles of Larynx. See Larynx, p. 417.

DEEP LATERAL MUSCLES OF NECK

Scalenus Anterior lies under cover of sterno-mastoid. **Origin** (fl.-tend.): ant. tubercles of 3rd, 4th, 5th, 6th cervical transverse processes. **Insertion** (tend.-fl.): scalene tubercle and adjoining ridge on upper surface of 1st rib, between subclavian art. and vein. **Nerves**: anterior rami of C. 4, 5, 6, directly. Elevates 1st rib. Bends neck to that side, and both muscles acting flex it slightly.

Anterior surface is in relation to sterno-mastoid, int. jugular vein (sometimes common carotid art.), ant. jugular vein, subclavian vein, thoracic duct, omo-hyoid, transverse scapular and cervical arteries, ascending cervical artery, phrenic nerve. **Posterior to it** are scalenus medius, roots of brachial plexus, subclavian art., cervical pleura.

Scalenus Medius lies in floor of post. triangle. **Origin** (fl.-tend.): post. tubercles of 2nd to 6th cervical transverse processes. **Insertion** (fl.-tend.): upper surface of 1st rib,

between groove for subclavian art. and tubercle of rib.
Nerves: anterior rami of C. 3 to 7 directly. Elevates 1st rib, bends neck to that side.

Cervical and brachial plexuses and subclavian art. lie on **anterior surface**; and omo-hyoid, transverse scapular and cervical vessels, and suprascapular nerve and lowest root of long thoracic nerve cross it. Levator scapulae and scalenus posterior lie **lateral** and **posterior** to it. Dorsalis scapulae nerve (n. to rhomboids) and upper two roots of long thoracic nerve *pierce* it.

Scalenus Posterior lies in posterior triangle of neck, posterior to medius and frequently blended with it. **Origin** (fl.-tend.): post. tubercles of 4th, 5th, 6th cervical transverse processes. **Insertion** (tend.): upper border of 2nd rib, behind tubercle for serratus anterior. **Nerves**: ant. rami of C. 5, 6, 7. Elevates 2nd rib; bends neck to that side.

Rectus Capitis Lateralis. —**Origin** (fl.-tend.): upper surface of transverse process of atlas. **Insertion** (fl.-tend.): lower surface of jugular process of occipital bone. **Nerve** ant. ramus of C. 1. It bends head to that side. It is homologous with post. intertransverse muscles. *Anterior* surface is related to internal jugular vein and the last four cerebral nerves at base of skull. *Posterior* surface is covered by obliquus superior. *Lateral* to it are occipital artery and posterior belly of digastric. *Medial* to it are vertebral vessels and anterior branch of 1st cervical nerve.

PREVERTEBRAL MUSCLES

Longus Colli lies on anterior aspects of cervical and upper thoracic vertebrae; attachments are tendinous and divided into three portions. *Lower oblique portion* **arises** from bodies of upper three thoracic vertebrae; **inserted** into ant. tubercles of 5th and 6th cervical transverse processes. *Vertical portion*, medial to oblique, **arises** from bodies of upper three thoracic and lower three cervical vertebrae; **inserted** into 2nd, 3rd, 4th cervical bodies. *Upper oblique portion* **arises** from ant. tubercles of 3rd, 4th, 5th cervical transverse processes, under cover of longus capitis; **inserted** into tubercle on ant. arch of atlas. **Nerves**: ant. rami of C. 3 to 8. Bends and rotates neck to same side.

Longus Capitis (Rectus capitis anticus major) lies on anterior aspect of upper cervical vertebrae. **Origin** (tend.), ant. tubercles of 3rd, 4th, 5th, 6th cervical transverse processes (cf. scalenus anterior). **Insertion** (fl.-tend.): lower surface of basi-occipital, anterior and lateral to pharyngeal tubercle. **Nerves**: ant. rami of C. 1 to 4. Flexes head; turns face to same side.

Rectus Capitis Anterior (Rect. cap. ant. minor) lies behind and lateral to longus capitis. **Origin** (fl.-tend.): ant. surface of lateral mass of atlas. **Insertion** (fl.-tend.) lower surface of basi-occiput, anterior to condyle. **Nerve**: ant. ramus of c. 1. Flexes head.

POSTERIOR TRIANGLE OF NECK

Boundaries.—*Posterior*: anterior border of trapezius. *Anterior*: posterior border of sterno-mastoid. *Base*: middle third of clavicle. *Roof*: deep cervical fascia, pierced at post. border of sterno-mastoid by ext. jugular vein and some of the superficial branches of cervical plexus, and, here and there, by lymphatics and cutaneous branches of occipital and transverse cervical and scapular vessels. Platysma covers lower part of roof, and, under platysma, supra-clavicular nerves lie on it after piercing, and ext. jugular vein for short distance, close to sterno-mastoid, before piercing. The triangle is crossed, after dissection, by posterior belly of omo-hyoid, which extends from postero-inferior angle forwards and upwards, and divides it into larger occipital triangle above, small subclavian triangle below:—

Occipital Triangle.—*Floor*: Splenius capitis, levator scapulæ, scalenus medius and posterior, from above downwards. Occasionally semispinalis capitis (complexus) appears in floor, at apex. **Contents**: occipital art. crosses apex. (Spinal) accessory n. and branches to trapezius from 3rd and 4th cervical nerves cross backwards and downwards, about middle of space, to reach trapezius. Branches from c. 3, 4 run across scalenus medius to levator scapulæ. Superficial cervical nerves are found above middle of post. border of sterno-mastoid; upper roots and trunks of brachial plexus at lower and medial angle. Transverse cervical art. and vein cross just above omo-hyoid. Lymph glands, areolar tissue, fat.

Subclavian Triangle.—*Floor*: scalenus medius and posterior, 1st rib, and 1st digitation of serratus anterior (magnus), especially on right side. **Contents**: subclavian art.; brachial nerve trunks posterior to artery and above it, subclavian vein below it, behind clavicle. Transverse scapular art. (supra-scapular) passes laterally, on anterior aspect of subclavian art., posterior to clavicle; nerve to subclavius descends vertically, anterior to subclavian art.; ext. jugular vein and its tributaries—transverse cervical and scapular, and ant. jugular veins—form plexus, also anterior to it. Transverse cervical art. may cross upper medial angle of space, before entering occipital triangle. Lymph glands, areolar tissue and fat.

Relations in Posterior Triangle of Neck

Third part of **subclavian artery** begins at lateral margin of scalenus anterior; passes downwards and laterally, and ends at outer

margin of 1st rib, by becoming axillary art. Usually no branch arises from third part, but occasionally it gives off a branch which takes the place of the descending branch (post. scapular) of transverse cervical.

Anterior to it, as it lies in the triangle, are skin, superficial fascia, platysma, deep fascia, ext. jugular vein and terminations of transverse scapular and cervical veins, and the nerve to subclavius. Its terminal part lies below the triangle; and the clavicle, subclavius and transverse scapular artery (supra-scapular) are anterior to it. Subclavian vein is anterior, but at a lower level. *Posterior to it* is scalenus medius, separated by first thoracic nerve or lowest trunk of brachial plexus. *Below it* are the first rib, and the pleura at the medial part of the artery, and both rib and pleura are also posterior to the artery.

Transversa colli artery (Transverse cervical) arises from thyreo-cervical trunk (thyroid axis), near medial margin of scalenus anterior; passes laterally and upwards across scalenus anterior and phrenic nerve, upper trunks of brachial plexus, nerve to subclavius, supra-scapular nerve, and scalenus medius to the anterior border of levator scapulæ, under cover of anterior border of trapezius, where it divides into ascending and descending branches. *Superficial to it* are sterno-mastoid and fasciæ. Omo-hyoid crosses it as the artery enters post. triangle. At its origin it is crossed by int. jugular vein, and, on the left side, by the thoracic duct also.

Ascending branch ramifies on deep surface of trapezius, superficial to levator scapulæ and splenius, and anastomoses with branches of occipital. **Descending branch** (posterior scapular) descends, under cover of levator scapulæ and the rhomboids, along vertebral margin of scapula, lateral to and close to dorsalis scapulæ nerve (nerve to rhomboids); sends branches to muscles on both surfaces of scapulæ; anastomoses with branches of circumflex scapular (dorsalis scapulæ), transverse scapular and subscapular, and intercostals. Its place may be taken by a branch from 3rd part of subclavian.

Transversa scapulæ artery (supra-scapular) arises from thyreo-cervical trunk, passes laterally and then dorsally, along root of neck, posterior to sterno-mastoid and clavicle, and below trapezius, to the upper border of scapula, where it passes above superior transverse lig. to enter supra-spinous fossa. There it gives off a branch and then enters infra-spinous fossa, through great scapular notch, under cover of inferior transverse lig. (gleno-humeral). It sends branches to muscles, clavicle, acromion, both surfaces of scapula, acromio-clavicular and shoulder joints; these anastomose with branches of thoraco-acromial (thoracic axis), post. humeral circumflex, subscapular, circumflexa (dorsalis) scapulæ, and descending branch of transverse cervical.

Relations.—While posterior to sterno-mastoid, it crosses scalenus anterior and phrenic nerve, above ant. jugular vein; and is crossed, near its origin, by int. jugular vein and, on left side, by thoracic duct and, as it passes from behind sterno-mastoid, it is crossed by ext. jugular vein. While posterior to clavicle, below posterior triangle, it runs

superficial to nerve to subclavius, 3rd part of subclavian artery, brachial plexus and scalenus medius. At lower posterior angle of post. triangle it joins supra-scapular nerve and omo-hyoid, and they leave scalenus and pass through areolar tissue above serratus anterior (magnus) and subscapularis, below trapezius, to reach scapula. At superior margin of scapula the artery passes above the superior transverse lig., the nerve passes through the notch below it, and on dorsal surface of scapula they are under cover of supra- and infra-spinatus muscles. Its vein may be above or below transverse lig., and in root of neck it lies above artery.

Transverse cervical and transverse scapular veins end in ext. jugular.

Subclavian vein, where it corresponds to third part of artery, lies on 1st rib, has subclavius and its nerve anterior to it, subclavian artery on a posterior plane, but on a higher level.

External jugular vein begins below and posterior to angle of mandible, below lobe of ear, by the union of the posterior auricular with a branch of the posterior facial which emerges from parotid gland. It descends almost vertically on superficial surface of sterno-mastoid, crossing it obliquely, under cover of platysma, and superficial or deep to nervus cutaneus colli (transverse superficial cervical). At posterior border of sterno-mastoid, a little above clavicle, it pierces deep fascia, crosses third part of subclavian artery and the transverse scapular artery, and ends behind clavicle in subclavian vein. It possesses a valve at its termination, and another at a higher level. It communicates with int. jugular by a branch which turns round ant. border of sterno-mastoid into carotid triangle. It receives a *posterior jugular vein* from back of neck; and, near its termination, the ant. jugular, and transverse cervical and scapular veins join it, and form with it a plexus, anterior to subclavian artery.

Accessory nerve (spinal accessory) emerges from substance of sterno-mastoid, about the junction of its upper and middle thirds; runs downwards and posteriorly, superficial to levator scapulæ, and disappears under cover of ant. border of trapezius, about the junction of its middle and lower thirds, or even lower. It supplies sterno-mastoid and trapezius. It is accompanied by branches from 3rd and 4th cervical, which communicate with it and form a plexus on the deep surface of trapezius.

The **superficial branches of cervical plexus** emerge from under cover of sterno-mastoid and appear at its posterior border, above its middle point. They are the lesser occipital and great auricular, which ascend; nervus cutaneus colli, which is horizontal; supra-clavicular nerves, which descend.

Lesser occipital nerve arises from 2nd cervical; runs upwards along post. border of sterno-mastoid, turns on to its superficial surface; pierces deep fascia, and is distributed to skin over occipital bone and mastoid temporal, and upper part of cranial surface of auricle; it communicates with greater occipital and great auricular.

Great auricular nerve arises from 2nd and 3rd cervical; turns

round sterno-mastoid ; ascends on its superficial surface, parallel to and posterior to ext. jugular vein ; pierces deep fascia and divides into mastoid, auricular and facial branches. **Mastoid branches** supply skin over mastoid region ; **auricular branches** supply lower $\frac{2}{3}$ of cranial surface of auricle and lower $\frac{1}{3}$ of its lateral surface ; both these communicate with lesser occipital and posterior auricular. **Facial branches** supply skin covering lower parts of parotid gland and masseter, and they send branches into parotid to communicate with facial nerve.

Nervus cutaneus colli (transverse superficial cervical) turns anteriorly across sterno-mastoid, about its middle, under cover of platysma, and either superficial or deep to ext. jugular vein. It pierces deep fascia and divides into two branches, which supply skin covering anterior triangle of neck, and the upper branch communicates with cervical branch of facial. It arises from 2nd and 3rd cervical.

Anterior, middle and posterior supra-clavicular nerves are branches of a common trunk which arises from 3rd and 4th cervical nerves, and appears at posterior border of sterno-mastoid below the other superficial nerves, and breaks up into its branches. They descend through lower part of posterior triangle, pierce deep fascia above clavicle, and passing through platysma, supply skin covering upper parts of pectoralis major and deltoid. The anterior branches cross sterno-mastoid and sternal third of clavicle ; the middle branches cross middle of clavicle, and one or more of them may pass through the clavicle ; the posterior branches cross trapezius and acromial third of clavicle.

Brachial plexus lies partly in antero-inferior part of posterior triangle, partly behind clavicle, and partly in axilla. It consists of roots, trunks, divisions, cords and branches.

Its **roots** are the anterior branches (ant. primary divisions) of the spinal nerves which form it. 5th cervical nerve receives a communication from 4th, and combines with 6th to form **upper trunk**. 7th cervical alone forms **middle trunk**. 1st thoracic nerve receives a communication from 2nd, gives off the first intercostal nerve, and combines with 8th cervical to form **lower trunk**.

Each trunk splits into an **anterior** and a **posterior division**. The upper two anterior divisions unite to form the **lateral cord**. Lower anterior division forms **medial cord**. All three posterior divisions unite to form **posterior cord**.

Relations.—**Above clavicle**, its *superficial relations* are skin, fasciæ, platysma, supra-clavicular nerves ; transverse cervical and scapular and ext. jugular veins, post. belly of omo-hyoid ; transverse cervical art., nerve to subclavius ; third part of subclavian artery. **Posterior to clavicle**, the lowest part of subclavian artery and transverse scapular (supra-scapular) art. are anterior. *Posterior to it* are scalenus medius and roots of long thoracic nerve (Bell).

Branches above Clavicle.—**Communicating.**—*Grey rami*

communicantes from middle cervical ganglion to 5th and 6th cervical nerves, from inferior ganglion to 7th and 8th, from first thoracic ganglion to 1st thoracic nerve.

Muscular Branches.—(I.) Root of phrenic from 5th. (II.) Branches to scalenus anterior from 5th and 6th; to scalenus medius and posterior from 5th, 6th, 7th; to longus colli from 5th, 6th, 7th, 8th. (III.) Dorsalis scapulæ nerve; nerve to subclavius; supra-scapular nerve; long thoracic nerve.

Dorsalis scapulæ nerve (nerve to rhomboids) arises from 5th cervical, pierces scalenus medius, passes under cover of levator scapulæ, and descends along vertebral margin of scapula under cover of levator scapulæ and rhomboideus minor and major, and supplies all three.

Nerve to subclavius arises from 5th or 5th and 6th cervical nerves, at their junction. It descends near lateral margin of scalenus anterior, and sometimes sends a branch on to its anterior surface to join phrenic; this takes the place of the root of phrenic from 5th. *Posterior to it* are the brachial plexus and subclavian vessels; *anterior to it* are omo-hyoid, transverse cervical and scapular vessels, and clavicle.

Supra-scapular nerve arises from 5th and 6th cervical nerves, at their junction, and runs obliquely downwards, laterally and posteriorly, on scalenus medius, just above and lateral to brachial plexus. It is crossed superficially by transverse cervical vessels. At postero-inferior angle of posterior triangle it passes deep to omo-hyoid and joins transverse scapular artery, which it accompanies to upper border of scapula. It passes beneath superior transverse lig. of scapula through the notch, and supplies supra- and infra-spinatus and the shoulder-joint.

Long thoracic nerve (Bell) arises by three roots from 5th, 6th, 7th cervical nerves. Roots from 5th and 6th pierce scalenus medius; root from 7th crosses it superficially. They leave scalenus and pass over 1st digitation of serratus anterior; unite to form one stem, which descends along axillary surface of serratus, supplying it.

ANTERIOR TRIANGLE OF NECK

Boundaries.—**Anterior**: middle line of neck. **Posterior**: ant. border of sterno-mastoid. **Base**: lower border of mandible, and line drawn from its angle to mastoid process. **Roof**: deep cervical fascia, covered in upper part by platysma. Ant. jugular vein lies on it near median plane; cervical branch of facial n. and n. cutaneus colli (transverse superficial cervical) run forwards under platysma. Most medial of supra-clavicular nerves may lie on lower part.

Anterior triangle is subdivided into four subsidiary triangles: muscular, carotid, digastric and submental.

Muscular Triangle.—*Bounded posteriorly* by sterno-mastoid; *anteriorly* by middle line of neck, below hyoid bone; *superiorly* by ant. belly of omo-hyoid. **Contents**: ant. jugular vein, sterno-hyoid

and sterno-thyreoid and their nerves. Deep to them, thyreoid gland and its arteries from sup. and inf. thyreoid, its middle and inferior thyreoid veins. Still deeper, lower part of larynx and pharynx, ext. laryngeal nerve; cervical parts of trachea, cesophagus, recurrent nerve and, on left side, thoracic duct; *and when sterno-mastoid is retracted*, common carotid art., int. jugular vein, vagus, ansa hypoglossi, sympathetic trunk, cervical cardiac nerves.

Relations in Muscular Triangle, Anterior Part of Root of Neck, and Superior Aperture of Thorax

Superior aperture of thorax (thoracic inlet) is bounded by 1st thoracic vertebra posteriorly, 1st costal arch on each side, manubrium sterni anteriorly. Owing to obliquity of aperture, structures which enter or leave thorax, at its anterior part, do so at the level of fibro-cartilage between 2nd and 3rd thoracic vertebrae, and the lower part of their cervical course is, therefore, opposite the first two thoracic vertebrae.

Note. — Unless otherwise specified, the relations given for structures found in both neck and thorax refer to the cervical part of their course and to the superior aperture of thorax.

Dome of pleura, with underlying lung, occupies, on each side, the lateral part of superior aperture of thorax, and is roofed over by *Sibson's fascia*, which spreads fanwise from 7th cervical transverse process to inner margin of 1st rib.

Longus colli, on each side, is ascending from thorax to neck, upon bodies of vertebrae, from 3rd thoracic to 1st cervical. **Sterno-hyoid** ascends from posterior surfaces of manubrium and clavicle to hyoid bone, near median plane. **Sterno thyreoid** ascends from posterior surfaces of manubrium and 1st cartilage, below sterno-hyoid, to oblique line on thyreoid cartilage. It is posterior and medial to sterno-hyoid *below*, lateral to it *above*. Both lie anterior to trachea and great vessels at root of neck, and to thyreoid gland and larynx higher up. They are largely concealed by clavicle and sterno-mastoid; **anterior jugular vein** passes laterally between these two muscles and sterno-mastoid, a little above clavicle. Posterior belly of **omo-hyoid** arises from superior margin and transverse lig. of scapula, runs across lower part of post. triangle of neck, ends under cover of sterno-mastoid in an intermediate tendon, from which anterior belly ascends over int. jugular vein, common carotid art., thyreoid gland and larynx, to hyoid bone, lateral to sterno-hyoid. Sterno-hyoid, sterno-thyreoid and omo-hyoid are supplied by ansa hypoglossi, i.e. the loop formed in front of common carotid, opposite lower part of thyreoid cartilage, by union of descendens hypoglossi and descendens cervicalis from 2nd and 3rd cervical nerves.

Remains of **thymus** are immediately *posterior to* sterno-hyoid and sterno-thyreoid, and to interfascial space above sternum containing

anastomosis between anterior jugular veins ; and *anterior to* trachea, inferior thyreoid veins, innominate and left common carotid arteries.

Trachea is passing from level of 6th vertebra downwards and slightly posteriorly, in the median plane. *Superficial to it* are deep fascia of neck, anastomosis between anterior jugular veins, sterno-hyoid and sterno-thyreoid ; isthmus of thyreoid gland on 2nd, 3rd and 4th rings ; pyramidal lobe and anastomosis between superior thyreoid vessels, above isthmus ; below isthmus, it is some distance from surface, and the thymus, inferior thyreoid veins, occasional thyroidea ima art., pretracheal fascia and lymph glands are near relations. *Lateral to it* are lobe of thyreoid gland, down to 5th or 6th ring ; innominate and common carotid arteries on right side, common carotid on left side ; pleura and lung on each side some distance away, at root of neck. *Posterior to it* are œsophagus and longus colli muscles, and recurrent nerve on each side, in the groove between margins of trachea and œsophagus.

Æsophagus is descending from level of 6th vertebra, upon longus colli, immediately posterior to trachea and recurrent nerves, and protruding a little to left side of trachea. On its right side are pleura and lung, at root of neck ; thyreoid gland and common carotid art., higher up. At superior aperture of thorax the left common carotid is anterior to its left border, and thoracic duct and left subclavian art. and pleura are on its left side. Higher up, the common carotid is on its left side, and both are overlapped by thyreoid gland.

Thyreoid gland, ensheathed in pretracheal fascia, which binds it to larynx, is related to upper part of trachea and lower part of larynx. Its **isthmus**, $\frac{1}{2}$ in. wide, $\frac{3}{4}$ in. deep, lies on 2nd, 3rd and 4th rings of trachea, covered by skin and fascia ; *pyramidal lobe* projects upwards from left side of upper border of isthmus, upon upper end of trachea, and is connected with hyoid by levator glandulae thyroideæ, or by a fibrous band ; along upper border of isthmus there is an anastomosis between opposite thyreoid arteries. **Lateral lobe**, on each side, extends from middle of thyreoid cartilage to 6th ring of trachea ; piriform in shape, apex upwards ; 2 in. long, $1\frac{1}{4}$ in. broad, $\frac{3}{4}$ in. thick. It is related *medially* to thyreoid cartilage, crico-thyreoid muscle, ext. laryngeal nerve, cricoid cartilage, trachea ; and to inferior constrictor, œsophagus and recurrent nerve. Related *posteriorly* to common carotid, inf. thyreoid art., longus colli. Covered *superficially* by sterno-thyreoid, sterno-hyoid, omo-hyoid, and their nerves from ansa hypoglossi, and it is overlapped by sterno-mastoid.

Nerves, from middle and inf. cervical ganglia, accompany arteries to thyreoid gland. **Lymphatics** end in deep cervical, prelaryngeal, pretracheal, paratracheal, upper mediastinal lymph glands.

Superior thyreoid branch of ext. carotid, having given off its hyoid, internal laryngeal, sterno-mastoid branches in carotid triangle, enters muscular triangle, and, under cover of omo-hyoid, sterno-hyoid and sterno-thyreoid, gives off (1) its crico-thyreoid branch, which

anastomoses with its fellow on crico-thyroid lig., and (2) terminal branches to thyroid gland and adjacent muscles. **Ext. laryngeal nerve** runs downwards and anteriorly, deep to and parallel to sup. thyroid art., upon inf. constrictor, then under cover of thyroid gland, in company with crico-thyroid art. It gives branches to inf. constrictor and ends in crico-thyroid muscle.

Inferior thyroid branch of thyreo-cervical trunk (thyroid axis), from subclavian, runs upwards along medial border of scalenus anterior to level of 6th vertebra, and sends ascending cervical branch upwards in front of transverse processes; turns medially, posterior to carotid sheath and middle cervical ganglion, anterior to vertebral art. and longus colli; reaches post. aspect of thyroid gland and runs downwards along it, giving (1) muscular branches to adjacent muscles; (2) inferior laryngeal branch, which enters larynx under cover of lower border of inferior constrictor; (3) branches to trachea and oesophagus; and (4) terminal branches to thyroid gland at its lower end. Recurrent nerve ascends either anterior or posterior to inf. thyroid art.; and on left side thoracic duct is anterior to the origin of the artery.

The occasional **thyroidea ima artery**, from innominate, ascends upon trachea, under cover of thymus, to reach thyroid gland.

Sup. thyroid vein emerges from under omo-hyoid, crosses common carotid in carotid triangle, and enters int. jugular vein. **Middle thyroid vein** crosses common carotid and ends in int. jugular, under cover of omo-hyoid. **Inf. thyroid veins** descend upon trachea, behind thymus, to end in innominates just below sup. thoracic aperture.

Pretracheal fascia is attached to thyroid and cricoid cartilages, envelops thyroid gland, descends upon trachea, posterior to inf. thyroid veins, and in thorax blends with pericardium.

Innominate artery, as it extends upwards and to the right, out of thorax into neck, passes from anterior surface to right side of trachea, from behind manubrium and left innominate vein to the back of sterno-clavicular joint, behind the upper border of which it ends by dividing into right common carotid and subclavian arteries. *Anterior to it* are thymus, sterno-thyroid, sterno-hyoid, sterno-clavicular joint, in that order from behind forwards. Trachea is on its *left* side; right innominate vein on its *right* side. *Posterior to it* some fatty areolar tissue separates it from longus colli, and sometimes from pleura and lung. The vagus is first lateral and then on a posterior plane, as it enters thorax and approaches the side of trachea.

Right common carotid artery runs upwards and slightly laterally, from sterno-clavicular joint to carotid triangle, to end by dividing into ext. and int. carotids, opposite upper border of thyroid cartilage and lower border of 3rd cervical vertebra. It is enclosed with int. jugular vein and vagus in carotid sheath, and gives no branches except its terminals. *Anterior to it*—sterno-mastoid, under cover of which the ant. jugular vein passes laterally; then come sterno-hyoid, sterno-

thyreoid, omo-hyoid; under cover of these are the middle thyreoid vein and ansa hypoglossi. Anterior to the small part of it in carotid triangle, the descendens hypoglossi descends vertically, the artery to sterno-mastoid and superior thyreoid vein cross laterally. *Medial to it* are trachea, œsophagus and recurrent nerve below, larynx and pharynx above. Thyreoid gland is medial and overlaps it anteriorly. *Posterior to it* are longus colli below, longus capitis (rectus cap. ant. major) above, sympathetic trunk all the way, recurrent nerve near its origin, and inf. thyreoid art. opposite cricoid cartilage and 6th vertebra. At their origin the subclavian artery is posterior to common carotid. *Lateral to it* is int. jugular vein, with vagus and cardiac nerves between it and artery, on a posterior plane. Vertebral artery is related to its lower part—at first postero-lateral, and then posterior to it.

Right subclavian artery arches laterally from sterno-clav. joint to outer border of 1st. rib, across dome of pleura, below and anterior to its apex, separated from it by Sibson's fascia. Scalenus anterior descends in front of it and divides it into 3 parts. **First part** extends from origin to scalenus anterior, and gives off vertebral and int. mammary arteries and thyreo-cervical trunk (thyroid axis). *Anterior to first part* are (1) sterno-mastoid; (2) the ant. jugular vein, under cover of sterno-mastoid; then (3) the sterno-hyoid and -thyreoid. *Posterior to these*, and close to the artery, are (4) the int. jugular vein; (5) right lymphatic duct, at medial margin of scalenus anterior; (6) vertebral vein, posterior to jugular; (7) vagus, medial to jugular vein; (8) a nerve cord descends from middle cervical ganglion, anterior to subclavian art., medial to vagus, and turns upwards, posterior to the artery, to join inf. ganglion; the loop so formed is the *ansa subclavia* (Vieussens). (9) Common carotid is anterior to subclavian at its origin. *Posterior and inferior to first part* are lung, pleura, Sibson's fascia, and, near its origin, the recurrent nerve and ansa subclavia; and, more laterally, the 1st intercostal vein sometimes. Cervical cardiac branches of vagus and sympathetic descend either anterior or posterior to the artery.

Second part lies behind scalenus anterior, is highest part of arch, $\frac{1}{2}$ inch above middle of sternal $\frac{1}{3}$ of clavicle, and gives off costo-cervical trunk (sup. intercostal). *Anterior to it* is scalenus anterior, in front of which, from above downwards, are transverse cervical and transverse scapular (supra-scapular) arteries, ant. jugular and subclavian veins, the subclavian vein being below the level of its artery; phrenic nerve descends between the transverse arteries and scalenus anterior, which separates it from 2nd part of subclavian on right side; sterno-mastoid covers all these. *Posterior and inferior* are Sibson's fascia, pleura and lung.

Third part. See Posterior Triangle of Neck, p. 204.

Right vertebral artery springs from upper and posterior aspect of subclavian, $\frac{1}{4}$ to $\frac{1}{2}$ inch from medial margin of scalenus anterior. Its *first part* extends upwards, surrounded by plexus of sympathetic nerves from inferior cervical ganglion; disappears into foramen of 6th cervical

transverse process, and gives no branches. Common carotid artery is antero-medial below, and anterior to it above; vagus, vertebral vein, and int. jugular vein are antero-lateral; inf. thyreoid artery crosses it anteriorly, just before it disappears. Thyreo-cervical trunk (thyroid axis) and scalenus ant. are lateral to it; longus colli and lower cervical part of sympathetic trunk are medial; pleura is posterior at its origin, and higher up the inf. cervical ganglion, 7th cervical transverse process and 7th cervical nerve are posterior to it.

Right vertebral vein emerges from 6th cervical transverse process, descends at first anterior, then lateral to vertebral artery, in front of pleura and subclavian artery, behind jugular vein; and ends in innominate. It receives (1) ant. vertebral vein, which accompanies ascending cervical art., and (2) deep cervical vein accompanying artery of same name, and sometimes (3) the first intercostal vein.

Right internal mammary artery arises from lower and anterior aspect of subclavian, at medial border of scalenus anterior, runs downwards, forwards, and medially, upon ant. surface of pleura, to enter thorax immediately posterior to 1st cartilage. Anterior to it are clavicle, termination of int. jugular, and commencement of innominate vein, from behind which it emerges as it enters thorax. While posterior to innominate vein it is crossed obliquely, latero-medially, by phrenic nerve, and gives off its pericardiaco-phrenic branch (art. comes n. phrenici). *Internal mammary vein* does not ascend into neck; it ends in innominate at superior aperture of thorax.

Right thyreo-cervical trunk (thyroid axis) arises from antero-superior aspect of subclavian, runs upwards for $\frac{1}{2}$ inch, between scalenus ant. and vertebral art., posterior to int. jugular vein, anterior to pleura; and divides into inf. thyreoid, transverse cervical and scapular. *Inferior thyreoid*, see p. 211. **Transverse cervical and transverse scapular** (supra-scapular) **arteries** run laterally, in front of scalenus ant. and phrenic nerve, posterior to sterno-mastoid, and pass into posterior triangle of neck (p. 205). Their veins end, in posterior triangle, by joining external jugular.

Right costo-cervical trunk arises from 2nd part of subclavian; ascends upon pleura, behind scalenus ant., to reach neck of 1st rib; and divides into two: **Deep cervical branch** passes dorsally, between neck of 1st rib and 7th cervical transverse process, and appears in back of neck, between semispinalis cervicis and semispinalis capitis (complexus). **Superior intercostal branch** turns downwards on anterior surface of neck of 1st rib, posterior to apex of pleura, between sympathetic trunk medially and 1st thoracic nerve laterally, and ends in branches for first two intercostal spaces. *First intercostal vein* ascends in company with superior intercostal artery, in front of neck of 1st rib, passes forwards above apex of pleura, and either ends in vertebral vein, or descends between subclavian artery and pleura to end in innominate vein.

Right internal jugular vein is usually larger than the left. In

lower half of its course it lies lateral to common carotid artery, enclosed with artery and vagus in carotid sheath. It ends behind clavicle by joining subclavian to form innominate. Near its lower end it inclines to the right slightly, so that there is a small interval between it and carotid artery. At or near its lower end there is a valve. *Anterior to it*, in this lower part of its course, are omo-hyoid, sterno-hyoid, sterno-thyroid; ant. jugular vein; sterno-mastoid and clavicle. Just above clavicle it lies opposite interval between the two heads of sterno-mastoid. *Medial to it* are common carotid, and, on a posterior plane, the vagus, between artery and vein. Vertebral artery is postero-medial to it. *Posterior to it* are pleura; subclavian artery, thyreo-cervical trunk and its three branches near their origins, and origin of int. mammary; scalenus anterior and phrenic nerve, which are overlapped by it; vertebral vein, which descends between it and subclavian artery.

Right subclavian vein lies on 1st rib, extending from its outer margin, where it is continuous with axillary, to medial margin of scalenus anterior, where it joins int. jugular to form innominate, anterior to the pleura, posterior to clavicle. It is much shorter than its artery, and is anterior to it and on a lower level. Its more distal part has subclavius and its nerve anterior to it, subclavian artery posterior to it; is joined by ext. jugular vein, and has a valve on distal side of the entrance of ext. jugular. Its more medial part is in front of scalenus anterior, which separates it from subclavian art., and behind clavicle and sterno-hyoid.

Right innominate vein is formed by union of int. jugular and subclavian, posterior to clavicle, near its sternal end. In neck, the pleura and lung, int. mammary art. and phrenic n. are posterior to it; clavicle, costo-clavicular lig., sterno-hyoid and sterno-thyroid are anterior to it; innominate artery is medial to it, and vagus is postero-medial. As it enters thorax, posterior to 1st cartilage, it slips from anterior aspect of pleura on to its medial aspect, and phrenic nerve appears from behind it to lie on its right side, between it and pleura; and mammary art. appears from behind it, at its lateral border, and remains anterior to pleura. In the neck it receives the vertebral and 1st intercostal veins, and right lymphatic duct.

Right phrenic nerve arises from 3rd, 4th, and 5th cervical nerves; descends upon scalenus anterior, behind sterno-mastoid, overlapped by int. jugular vein, crossed superficially by omo-hyoid, transverse cervical, and transverse scapular (supra-scapular) arteries, in that order from above downwards. It lies deep to fascia covering scalenus ant. Immediately below level of subclavian art. it passes off scalenus on to pleura, behind innominate vein, and crosses int. mammary art. from lateral to medial side, usually anterior to it, but often behind it; leaves post. aspect of innominate vein to enter thorax, on lateral aspect of vein, between it and pleura, a little posterior to 1st cartilage, and accompanied by pericardiac-phrenic branch of int. mammary art.

Right vagus nerve, in lower part of neck, lies between, and

posterior to, common carotid and int. jugular, in carotid sheath; crosses inf. thyroid art., descends anterior to pleura, vertebral artery and vein; crosses anterior to subclavian artery; passes downwards, backwards, and medially between innominate artery and vein to enter thorax and gain the side of trachea. **Right recurrent nerve** arises from vagus as it crosses subclavian art. It turns backwards below subclavian, then upwards and medially between subclavian and pleura, and passes posterior to common carotid, near its origin, to reach groove between trachea and œsophagus, in which it ascends, medial to common carotid and thyroid gland, and anterior or posterior to inferior thyroid artery; passes under cover of lower border of inf. constrictor, as *inf. laryngeal*, to supply all laryngeal muscles, except cricothyroid. It gives branches also to inf. constrictor, œsophagus, trachealis muscle, and cardiac branches, which enter thorax upon the side of trachea, and end in deep cardiac plexus.

Cervical cardiac branches of right vagus and sympathetic descend upon pleura, anterior or posterior to subclavian artery, and accompany vagus to trachea.

Middle cervical ganglion lies on inferior thyroid artery, posterior to common carotid, opposite cricoid cartilage and 6th vertebra. It gives off *grey rami communicantes* to 5th and 6th cervical nerves, *thyroid branches*, which accompany inf. thyroid art., and the *middle cardiac nerve*.

Inferior cervical ganglion lies between 7th cervical transverse process and neck of 1st rib, anterior to 8th cervical nerve, posterior to vertebral artery. It gives off *grey rami communicantes* to 7th and 8th cervical nerves, an *inferior cardiac nerve*, a *plexus* to accompany vertebral artery. It may be fused with 1st thoracic ganglion on anterior aspect of neck of 1st rib, medial to superior intercostal artery; or the trunk descends into thorax, on front of neck of first rib, to join 1st thoracic ganglion. The part of **sympathetic trunk** connecting middle with inferior ganglion lies on longus colli, posterior to common carotid, close to medial side of vertebral artery. Another strand descends from middle ganglion, emerges from behind common carotid, crosses anterior to subclavian art., gives twigs to it and its branches, hooks round it, lateral to recurrent nerve, to form **ansa subclavia** (Vieussens), and ends in inferior ganglion.

First thoracic nerve gives off the 1st intercostal nerve, and passes obliquely, laterally and upwards, lateral to superior intercostal art., across anterior surface of junction of neck and body of 1st rib, to join brachial plexus. Sympathetic trunk, sup. intercostal art. and 1st thoracic nerve lie on anterior surface of neck of 1st rib, in that order medio-laterally, and all posterior to apical extremity of pleura.

Right lymphatic duct, rarely seen in an ordinary dissection, ascends out of thorax into neck, upon longus colli, to the right of the œsophagus, arches laterally behind carotid sheath, reaches medial border of scalenus anterior, is joined there by common jugular and

subclavian lymph trunks, descends for $\frac{1}{2}$ inch, anterior to subclavian artery, lateral to int. jugular vein and ends in innominate. The part of the duct between its origin in thorax and the medial border of scalenus anterior is called the *broncho-mediastinal trunk*; jugular and subclavian lymph trunks may end independently.

Several **lymph glands** lie in relation to the various vessels in lower part of neck and superior aperture of thorax.

Left common carotid artery springs from aortic arch and enters neck, opposite lower part of sterno-clavicular joint, and runs upwards and slightly laterally to end by dividing into ext. and int. carotids, opposite upper border of thyroid cartilage and lower border of 3rd vertebra. It gives off no branches except these. Except at lower end, it is enclosed, with vagus and int. jugular vein, in carotid sheath. *Anterior to it* are (1) sterno-clavicular joint, sterno-mastoid; (2) ant. jugular vein, as it passes laterally behind sterno-mastoid above clavicle; (3) sterno-hyoid, sterno-thyroid, omo-hyoid; (4) remains of thymus, at root of neck; (5) left innominate vein, posterior to thymus, just above or at sup. thoracic aperture; (6) middle thyroid vein crosses it, and ansa hypoglossi lies on it, beneath omo-hyoid, opposite lower part of thyroid cartilage. Anterior to the small part of it in carotid triangle are superior thyroid vein, and artery to sterno-mastoid, which cross it; descendens hypoglossi, which descends upon it.

Medial to it are trachea; recurrent nerve and œsophagus, below; larynx and pharynx, above; thyroid gland is both medial and anterior.

Posterior to it are the sympathetic trunk; longus capitis (rect. cap. ant. major) above, longus colli below; inf. thyroid art., opposite cricoid and 6th vertebra; thoracic duct, opposite 7th vertebra; at root of neck the subclavian and then the vertebral arteries are postero-lateral to it; higher up the vertebral artery becomes directly posterior.

Lateral to it are the vagus, cervical cardiac nerves, internal jugular vein, which overlaps it anteriorly, especially at lower end; and, at root of neck, the pleura is lateral.

Left subclavian artery springs from aortic arch and enters neck, postero-lateral to common carotid; ascends for a short distance, and then arches laterally over anterior surface of cervical pleura; crosses 1st rib and ends at its outer border by becoming axillary. Scalenus anterior descends in front of it and divides it into 3 parts: first part up to scalenus, second part behind it, third part beyond.

Just above sup. thoracic aperture, while first part is still ascending, it lies in a groove on medial surface of pleura and lung, at left side of œsophagus, with thoracic duct *posterior* to it, common carotid *antero-medial* to it, the vagus nerve, int. jugular and innominate veins *anterior* to it. Cervical cardiac branches of vagus and sympathetic are either anterior or posterior to it.

As it arches laterally, pleura is posterior and inferior, ansa subclavia

(Vieussens) loops round it; and 1st intercostal vein is sometimes posterior to it. And *anterior to it* are the int. jugular vein, vertebral vein, behind the jugular; phrenic nerve and thoracic duct, lateral to jugular. Further anterior relations as on right side: sterno-hyoid, sterno-thyroid, omio-hyoid, ant. jugular vein, sterno-mastoid. Note that thoracic duct arches from posterior aspect of ascending part to anterior aspect of transverse part. Second part of artery has same relations as on right side, except that phrenic nerve passes off scalenus anterior before it reaches level of subclavian artery, and is therefore an anterior relation not of the second but of the first part.

Left vertebral and internal mammary arteries, thyreo-cervical and costo-cervical trunks, and vertebral and 1st intercostal veins resemble those of right side, except that costo-cervical (superior intercostal) may arise from first part instead of second; and mammary is posterior to subclavian vein instead of posterior to jugular, before it becomes posterior to innominate, and phrenic nerve crosses it higher up.

Left internal jugular vein resembles that of right side, except that it is usually smaller, and, as both veins trend to the right, near their lower ends, the left vein overlaps the common carotid art., while the right is separated from the artery by an interval; and left vagus is posterior to the left vein.

Left subclavian vein resembles that of right side, except that in order to reach the jugular it extends beyond the medial margin of scalenus anterior and lies on pleura, phrenic nerve and int. mammary artery.

Left innominate vein is formed by the union of int. jugular and subclavian, behind clavicle near its sternal end. It passes downwards and to the right into thorax, behind manubrium and then, to the right and downwards, almost horizontally, near upper border of manubrium, and joins the right vein to form sup. vena cava, behind lower border of 1st right cartilage. In the neck, the clavicle and sterno-clavicular joint, sterno-hyoid and sterno-thyroid, and thymus are *anterior to it*, while *posterior to it* are pleura, int. mammary art., phrenic and vagus nerves, cardiac branches of vagus and sympathetic; subclavian and common carotid arteries. In the thorax, the manubrium, 1st right cartilage, both sterno-thyroids and the thymus are *anterior to it*, and its termination is overlapped by right pleura; while *posterior to it* are the left common carotid, trachea and pretracheal fascia, and innominate artery; and the aortic arch is *inferior to it*.

Left phrenic nerve differs from the right in that (1) it leaves the scalenus anterior at a higher level and crosses anterior to 1st part of subclavian artery, at medial border of scalenus; (2) it is crossed by the thoracic duct; (3) it is posterior to termination of subclavian vein before it becomes posterior to innominate; (4) it enters thorax anterior to ascending part of subclavian art., after escaping from under cover of innominate vein.

Left vagus nerve differs entirely from the right after it reaches subclavian artery. It descends anterior to ascending part of subclavian

art., postero-lateral to common carotid, posterior to int. jugular and innominate veins.

Left recurrent nerve arises in thorax, and already lies in the groove between trachea and œsophagus when it enters neck, and is therefore not posterior to subclavian and carotid arteries in the root of the neck.

Thoracic duct ascends into neck on left border of œsophagus, having subclavian artery anterior to it, pleura on its left side, longus colli posterior to it. At level of 7th cervical vertebra it arches laterally above pleura, posterior to common carotid art., vagus, cardiac nerves and int. jugular vein; anterior to sympathetic trunk, vertebral vessels (sometimes between art. and vein) and inf. thyreoid art.; turns downwards, anterior to transverse cervical and transverse scapular (supra-scapular) arteries, phrenic nerve, medial border of scalenus anterior, behind sterno-mastoid; receives jugular lymphatic trunk conveying lymph from left side of head and neck, subclavian lymphatic trunk conveying lymph from left upper limb; bends more medially and crosses anterior to subclavian artery, to end in junction of subclavian and jugular veins. It may break up into two or more trunks before ending, and subclavian and jugular trunks may end independently in one or other of the large veins.

The description given for *cardiac nerves*, *sympathetic trunk*, and *1st thoracic nerve* on right side of root of neck and superior aperture of thorax will serve for those on the left side.

Carotid Triangle.—*Bounded posteriorly* by sterno-mastoid, *superiorly* by stylo-hyoid and post. belly of digastric, *inferiorly* by ant. belly of omo-hyoid. **Floor:** *anteriorly*, thyreo-hyoideus, hyoid bone, and often a small part of hyoglossus; *posteriorly*, inf. and middle constrictors, and thyreo-hyoid membrane in gap between them. **Contents:** sup. thyreoid, lingual, ext. maxillary (facial) arteries directed forwards; sup. thyreoid, lingual, common facial veins directed backwards; hypoglossal nerve running horizontally forwards at lower border of digastric; int. laryngeal nerve and vessels piercing thyreo-hyoid membrane; ext. laryngeal nerve running downwards and forwards on inf. constrictor; upper part of larynx; nerve to thyreo-hyoid entering that muscle; lymph vessels and glands, areolar tissue, fat. *And when sterno-mastoid is retracted:* common, ext., int. carotids, inter-carotic body; occipital art. directed backwards; asc. pharyngeal art. directed upwards, deep to carotids; int. jugular vein, vagus, sympathetic trunk, upper cervical cardiac branches of vagus and sympathetic, descendens hypoglossi and cervicalis; (spinal) accessory n. at upper lateral angle.

Relations in Carotid Triangle

Only a small part of **common carotid artery** is in triangle. *Superficially*, it is overlapped by sterno-mastoid; descendens hypoglossi runs downwards on its anterior surface, and artery to sterno-mastoid and superior thyroid vein cross it, near omo-hyoid. *Medial to it* are the thyroid cartilage and inferior constrictor. *Posteriorly*, it rests on longus capitis (rectus capitis anticus major), sympathetic trunk intervening. *Lateral to it* is the int. jugular vein, and vagus nerve is between artery and vein, on a posterior plane.

Internal carotid artery, in the triangle, is overlapped by sterno-mastoid, and is enveloped with int. jugular vein and vagus in the carotid sheath. *Anteriorly*, it is crossed by lingual and common facial veins, hypoglossal nerve and occipital artery, in that order from below upwards. Descendens hypoglossi runs downwards on its anterior surface, deep to these veins; parotid gland overlaps it at upper part of triangle. *Medial to it* are inferior constrictor, ascending pharyngeal art., int. and ext. laryngeal nerves. *Posterior to it* are longus capitis, sympathetic trunk, and superior laryngeal nerve. *Lateral to it* is the internal jugular vein; and the vagus descends between them on a posterior plane. It gives no branches in the triangle.

External carotid artery is antero-medial to int. carotid, and gives off five branches in carotid triangle—superior thyroid, lingual, ext. maxillary (facial), ascending pharyngeal, occipital.

Superficially, it is overlapped by sterno-mastoid, and it is crossed by lingual and common facial veins, and hypoglossal nerve. Parotid gland overlaps it at upper part of triangle and post. facial vein crosses it from behind forwards. *Deep to it* are inferior constrictor and external and internal laryngeal nerves.

Superior thyroid artery runs downwards and anteriorly, superficial to inferior constrictor and ext. laryngeal nerve, and leaves the triangle by passing under cover of ant. belly of omo-hyoid. In the triangle it gives off (1) **hyoid branch**, which runs along lower border of hyoid bone, under cover of thyreo-hyoid muscle; (2) **superior laryngeal branch**, which passes under cover of posterior border of thyreo-hyoid muscle, pierces thyreo-hyoid membrane to enter pharynx, in company with int. laryngeal nerve; (3) **sterno mastoid branch**, which runs along upper border of omo-hyoid, across common carotid and int. jugular, and enters sterno-mastoid muscle.

Lingual artery arises opposite tip of greater horn of hyoid bone, forms a loop above the horn, convex upwards, which lies on middle constrictor, is crossed superficially by hypoglossal nerve and sends a **hyoid branch** along upper border of hyoid bone. Lingual artery disappears under cover of hyoglossus muscle.

External maxillary artery (facial) leaves the triangle at once by

passing under cover of posterior belly of digastric, superficial to middle constrictor.

Occipital artery arises opposite ext. maxillary, and passes backwards and upwards, along or under cover of lower border of post. belly of digastric. *Deep to it*, in the triangle, are the int. carotid artery, hypoglossal nerve, int. jugular vein, accessory nerve, in succession. Hypoglossal nerve is not only deep to it, but hooks round it, and as it does so the artery sends a branch across the int. jugular vein to sterno-mastoid, and sends meningeal branches upwards along int. jugular vein, to enter skull through jugular foramen; and as the artery crosses accessory nerve it often sends another branch to sterno-mastoid, along the accessory nerve. See also p. 230.

Ascending pharyngeal artery arises near lower end of ext. carotid; runs upwards on side of pharynx, at first opposite interval between int. and ext. carotids, and then medial to int. carotid.

Internal jugular vein is under cover of sterno-mastoid, and does not appear in triangle, unless the muscle is well retracted, except at upper angle of triangle. *Superficial to it* are numerous lymph glands; at upper posterior angle of triangle it is overlapped by lower end of parotid, and crossed by occipital artery and its artery to sterno-mastoid, and by spinal accessory nerve, which, however, may cross deep to it. Lower down, two small branches, from 2nd and 3rd cervical nerves, run obliquely downwards and medially, superficial to the vein, or medial to it, and unite to form the descendens cervicalis, which joins descendens hypoglossi. At lower part of triangle, the branch of superior thyreoid art. to sterno-mastoid crosses the vein. *Medial to it* are the int. and common carotid arteries, with vagus on a posterior plane. *Posterior to it* are cervical transverse processes, ascending cervical artery, origins of longus capitis (rectus cap. anticus major), levator scapulæ, scalenus medius and anterior, cervical plexus, phrenic nerve. *Lateral to it* are lymph glands and the overlapping sterno-mastoid.

Its **tributaries** in the triangle are pharyngeal, common facial, lingual, superior thyreoid and a communication from external jugular.

Pharyngeal veins are usually irregular, and pass, some superficial to the carotids and some deep to them, to join int. jugular.

Posterior facial vein (ant. branch of temporo-maxillary) emerges from under cover of parotid, passes downwards and anteriorly, superficial to ext. carotid, to join ant. facial. **Anterior facial vein** descends superficial to submaxillary gland and post. belly of digastric, enters carotid triangle and joins posterior facial to form **common facial vein**, which runs backwards, across external and internal carotids, to join internal jugular vein.

Lingual vein is formed at posterior border of hyoglossus by union of venæ comites of lingual artery with vein or veins accompanying hypoglossal nerve; and it either joins common facial, or crosses ext. and int. carotids to join int. jugular vein.

Superior thyreoid vein crosses common carotid, above anterior belly of omo-hyoid, to join int. jugular.

Communicating branch from ext. jugular turns round the ant. border of sterno-mastoid, to join int. jugular at upper part of triangle.

Sympathetic trunk descends posterior to int. and common carotids, anterior to longus capitis (rect. cap. ant. major) and longus colli, medial to vagus.

Vagus nerve descends posterior to and between carotid arteries and int. jugular vein, anterior to longus capitis and colli.

Superior cervical cardiac branches of vagus and sympathetic descend in company with these nerve trunks.

Superior laryngeal nerve arises from vagus, passes posterior to int. carotid, to lie between it and middle constrictor and divide into int. and ext. laryngeal branches. **Internal laryngeal nerve** passes from middle constrictor on to thyreo-hyoid membrane, and pierces it, under cover of posterior border of thyreo-hyoid muscle, in company with superior laryngeal art. **External laryngeal nerve** runs downwards and medially upon the inf. constrictor, deep to superior thyreoid artery; disappears under cover of omo-hyoid muscle and thyreoid gland; gives a branch to inf. constrictor, and ends in crico-thyreoid.

Accessory nerve passes either superficial or deep to int. jugular vein, and deep to occipital artery, and crosses upper or posterior angle of carotid triangle, accompanied by a sterno-mastoid branch of occipital artery, to reach sterno-mastoid.

Hypoglossal nerve appears from under cover of post. belly of digastric, between int. jugular vein and int. carotid artery, turns forwards, hooking round occipital artery and its first sterno-mastoid branch; crosses superficial to occipital artery, int. and ext. carotid arteries, and the loop of lingual artery, which separates it from middle constrictor, and disappears from the triangle by passing under cover of post. belly of digastric again. **Ramus descendens** arises from hypoglossal as it crosses int. carotid. It runs downwards, superficial to internal and common carotids, and is joined by descendens cervicalis to form ansa hypoglossi. **Thyreo-hyoid branch** arises before the hypoglossal crosses the lingual artery. It runs downwards and medially, superficial to lingual art., middle constrictor, and thyreo-hyoid membrane, to enter the thyreo-hyoid muscle.

Digastric or Submaxillary Triangle. *Bounded superiorly* by mandible and line drawn from its angle to mastoid process, *anteriorly* by ant. belly of digastric, *posteriorly* by stylo-hyoid and post. belly of digastric. **Floor:** mylo-hyoid, hyo-glossus, and superior constrictor, from before backwards. Triangle is subdivided by stylo-mandibular lig. into anterior and posterior parts. **Contents of anterior part:** submaxillary salivary and lymph glands; ant. facial vein, superficial to gland; ext. maxillary art. (facial), imbedded in gland; submental vessels, vessels and nerve

to mylo-hyoid, hypoglossal nerve deep to gland. **Contents of posterior part:** parotid gland. Deep to it, ext. carotid sending post. auricular art. backwards. Deep to these, when stylo-hyoid and digastric are retracted—int. carotid, separated from external by stylo-pharyngeus and glosso-pharyngeal n. ; int. jugular vein, vagus, hypoglossal and accessory nerves.

Submental Triangle is *bounded* by ant. belly of digastric, median line of neck, hyoid bone. Mylo-hyoid forms its **floor**. **Contents:** a few lymph glands, supra-hyoid branch of lingual art. The submental triangles of the two sides are usually looked upon as one, consisting of two symmetrical halves.

Relations in Submaxillary Space

Submaxillary space includes the anterior part of submaxillary triangle and the submental triangle, and contains the structures in relation to the mylo-hyoid and hyo-glossus muscles.

Mylo-hyoid forms, with its fellow, the diaphragm of the mouth. It arises from mylo-hyoid line of mandible, and is inserted into body of hyoid bone, and into the median raphe which extends from symphysis menti to hyoid bone. It is supplied by mylo-hyoid branch of inf. alveolar (dental) nerve, and it elevates hyoid bone and tongue.

Relations. — *Superficial:* Anterior belly of digastric crosses it obliquely. Submaxillary salivary gland and lymph glands lie on it, postero-lateral to ant. belly; and submental lymph glands lie on it, near median plane. Mylo-hyoid nerve and vessels run downwards and medially below its origin. Submental vessels sometimes lie between it and submaxillary gland. Mandible, deep fascia, cervical branch of facial nerve, and platysma are more superficial still.

Deep: Genio-hyoid, at the side of median plane; genio-glossus, posterior to genio-hyoid. Anterior part of hyo-glossus is between genio-glossus and posterior part of mylo-hyoid. Sublingual gland lies between mylo-hyoid and upper, anterior part of genio-glossus. Lingual nerve, duct and deep part of submaxillary gland, hypoglossal nerve and its vena comitans are between mylo-hyoid and hyo-glossus, in that order from above downwards. Sublingual artery runs to sublingual gland between mylo-hyoid and genio-glossus, below the level of lingual nerve. Mucous membrane of mouth covers deep surface of mylo-hyoid, near its origin, posteriorly.

Hyo-glossus arises from body and greater horn of hyoid bone, and is inserted into side of tongue near its base. It is supplied by hypoglossal nerve. It elevates hyoid bone, depresses tongue.

Relations. — *Superficial:* Mylo-hyoid anteriorly, submaxillary gland posteriorly, stylo-hyoid and tendon of digastric on postero-inferior part. Stylo-glossus interlaces with it at insertion into tongue, and they

are covered by mucous membrane of mouth. Below that is lingual nerve, with submaxillary ganglion suspended from it; then the deep part of submaxillary gland and the duct; and near the hyoid bone are the hypoglossal nerve and its vena comitans; and hyoid branch of lingual art., at the origin of the muscle.

Deep to it are the genio-glossus, and, at its lower and posterior part, the origin of middle constrictor. Between hyo-glossus and genio-glossus, the glosso-pharyngeal nerve runs anteriorly and upwards into tongue, the stylo-hyoid lig. runs downwards and anteriorly to lesser horn of hyoid bone. Lingual artery runs anteriorly above hyoid bone, on middle constrictor and genio-glossus, under cover of hyo-glossus, and then, as profunda linguae, it runs up to tongue, along anterior border of hyo-glossus; it is accompanied by vena comitans; its dorsales linguae branches ascend, under cover of hyo-glossus, to dorsum of tongue.

Submaxillary gland consists of a large superficial part and a small deep part. **Superficial part** lies partly under cover of mandible and pterygoideus internus, and partly in submaxillary triangle, overlapping the bellies of digastric. It is enclosed in two layers of fascia which extend from greater horn of hyoid bone, the one to lower border of mandible, the other to mylo-hyoid line. Its posterior end is separated from parotid gland by stylo-mandibular ligament.

Infero-lateral surface is covered by platysma and deep fascia; cervical branch of facial nerve crosses it, from behind forwards, under cover of platysma; ant. facial vein crosses its posterior part, from above downwards, under cover of deep fascia. Submaxillary lymph glands lie on upper part of this surface, along lower border of mandible.

Lateral surface lies against mandible and lower end of pterygoideus internus. Ext. maxillary (facial) artery, having emerged from groove on medial surface, turns downwards and forwards, between lateral surface of gland and pterygoideus internus, to reach lower border of mandible; mylo-hyoid vessels and nerve lie between mandible and gland, before reaching medial surface of gland.

Medial surface lies upon mylo-hyoid anteriorly, hyo-glossus posteriorly, and it overlaps digastric. Between it and mylo-hyoid are the mylo-hyoid vessels and nerve. Between it and hyo-glossus, from above downwards, are stylo-glossus and lingual nerve, submaxillary ganglion, hypoglossal nerve and vena comitans. Ext. maxillary art. ascends in a deep groove on posterior part of this surface. *Upper border* of the part that lies on hyo-glossus is in relation with mucous membrane of mouth.

Deep part of gland is a flat, oblong prolongation forwards from medial surface of gland. It lies under cover of mylo-hyoid, upon hyo-glossus and genio-glossus. It is accompanied by the duct and the lingual nerve, which are medial to it.

Arteries branches of ext. maxillary (facial) and its submental

branch. *Lymphatics* end in upper deep cervical lymph glands. *Nerves*: from lingual and sympathetic plexus around ext. maxillary art., through submaxillary ganglion.

Submaxillary duct (Wharton's) emerges from medial surface of gland; accompanies deep part of gland under cover of mylo-hyoid; passes deep to sublingual gland to open on caruncula sublingualis, at side of frenulum linguae. Hyo-glossus and genio-glossus are medial to it. Hypoglossal nerve is below it. Lingual nerve, at first above it, crosses it superficially at ant. border of hyo-glossus, and then turns upwards, deep to it and sublingual gland.

Sublingual gland lies under plica sublingualis in floor of mouth, where it can be felt by the tip of the down-turned tongue. It is almond-shaped, and about $1\frac{1}{2}$ inches long. Its *upper border* is covered by mucous membrane of floor of mouth; its *lower border* rests on mylo-hyoid. Its *lateral surface* lies against sublingual fossa of mandible, *i.e.* near symphysis, above mylo-hyoid line. Its *medial surface* lies against genio-glossus, the lingual nerve and submaxillary duct intervening, and near its upper border it is in contact with its fellow, above the level of genio-glossus. It has no fascial sheath.

Its **ducts**, 8 to 20 in number, open on plica sublingualis.

Arteries, from lingual and submental. *Lymphatics* end in submaxillary glands. *Nerves*, from lingual n. and submaxillary ganglion.

External maxillary artery (facial) arises from ant. aspect of ext. carotid in carotid triangle, and at once proceeds vertically upwards, under cover of posterior belly of digastric, stylo-hyoid, and angle of mandible, being enveloped in a deep groove on medial aspect of posterior part of submaxillary gland, above the level of stylo-hyoid; deep to it are the middle and superior constrictors, the sup. constrictor separating it from palatine tonsil. It emerges from groove in submaxillary gland and runs downwards and forwards, between pterygoideus internus and submax. gland, to lower border of mandible, where it turns upwards and enters face at ant. border of masseter.

Branches in neck: ascending palatine, tonsillar, glandular (submaxillary), submental.

Ascending palatine artery ascends between pterygoideus internus and superior constrictor, and between stylo-glossus and stylo-pharyngeus, and reaches apex of petrous temporal, where it turns downwards along levator v. palatini, and, passing over upper border of superior constrictor, pierces pharyngeal aponeurosis, and ends in velum palatinum (soft palate).

Tonsillar artery ascends between pterygoideus int. and stylo-glossus, turns medially, pierces sup. constrictor and enters palatine tonsil.

Glandular branches supply submaxillary gland.

Submental artery arises near lower border of mandible, runs anteriorly, either between submaxillary gland and mylo-hyoid, or between gland and mandible, and turns upwards on to chin.

Lingual artery arises from ant. aspect of ext. carotid, below external maxillary (facial), opposite tip of greater horn of hyoid ; it is divided into two parts. **First part** is in carotid triangle and forms a loop, convex upwards, above greater horn of hyoid, below posterior belly of digastric ; middle constrictor is medial, *i.e.* deep to it ; hypoglossal nerve crosses it superficially. **Second part** runs anteriorly, along upper border of hyoid, lying upon middle constrictor and genio-glossus, under cover of hyo-glossus, which separates it from hypoglossal nerve and its accompanying vein or veins, and from digastric and stylo-hyoid muscles and submaxillary gland. At anterior border of hyo-glossus it becomes the **profunda linguæ artery**, which runs upwards, between anterior border of hyo-glossus and genio-glossus, to the tongue, and then forwards to tip of tongue, having inferior lingual muscle above and lateral to it, profunda linguæ vein and mucous membrane of inf. surface of tongue below it, and genio-glossus medial to it.

Branches.—Hyoid branch from 1st part ; dorsales linguæ from 2nd part ; sublingual from 2nd part or from profunda.

Hyoid branch runs along upper border of hyoid, superficial to hyo-glossus. **Dorsales linguæ**, two or more, run upwards, between hyo-glossus and genio-glossus, to pharyngeal part of dorsum of tongue and to palatine tonsil. **Sublingual artery** arises from end of 2nd part or beginning of profunda, and runs upwards and anteriorly, between mylo-hyoid and genio-glossus, below the level of submaxillary duct and lingual nerve, to reach the sublingual gland.

Lingual Veins.—**Venæ comites** accompany lingual artery ; a **vena comitans** accompanies hypoglossal nerve ; the *largest vein* from tongue lies usually on lateral surface of hyo-glossus, below hypoglossal nerve. These all unite at posterior border of hyo-glossus to form **lingual vein**, which ends in common facial vein, or runs across carotids to end in internal jugular vein.

Lingual nerve leaves infra-temporal region (pterygo-maxillary space) by passing from between mandible and pterygoidens internus ; it then crosses superficial to attachment of superior constrictor to posterior end of mylo-hyoid line, under cover of mucous membrane of mouth, behind last molar tooth. It enters submaxillary space by crossing stylo-glossus superficially, at side of tongue ; and it runs anteriorly, close to the tongue, between mylo-hyoid and hyo-glossus, below mucous membrane of mouth, above submaxillary ganglion and duct of submaxillary gland. At anterior border of hyo-glossus it crosses submaxillary duct superficially from above downwards, and runs onwards between sublingual gland and genio-glossus. Under cover of sublingual gland it crosses deep to submaxillary duct, from below upwards ; and its terminal branches proceed, under cover of mucous membrane, as far as tip of tongue.

Branches.—In infra-temporal region it receives chorda tympani and communicates with inf. alveolar (dental). In submaxillary region it sends communicating branches to hypoglossal, along ant. border of

hyo-glossus ; gives communicating branches to, and receives one from, submaxillary ganglion ; gives branches to sublingual gland, mucous membrane of gums, floor of mouth and anterior $\frac{2}{3}$ of tongue.

Submaxillary ganglion is suspended by communicating branches from lingual nerve. It lies on hyo-glossus, under cover of submaxillary gland, above origin of its duct. *Roots* : sympathetic from plexus around ext. maxillary (facial) artery ; sensory from lingual ; secretory from chorda tympani, through lingual. *Branches* : to submaxillary gland and duct ; to mucous membrane of mouth ; to sublingual gland and tongue, through its communicating branch to lingual.

Hypoglossal nerve leaves carotid triangle by crossing the loop of lingual artery and disappearing under cover of posterior belly of digastric and stylo-hyoid, between them and hyo-glossus. In submaxillary region it passes anteriorly, first between submaxillary gland and hyo-glossus, and then between mylo-hyoid and hyo-glossus. It is accompanied by a small vein. Having crossed hyo-glossus it sinks through the substance of genio-glossus to supply all intrinsic muscles of tongue. While in submaxillary space it supplies genio-hyoid, and all extrinsic muscles of tongue, except glosso-palatinus (palato-glossus), namely, stylo-glossus, hyo-glossus, genio-glossus. Its branch to genio-hyoid (and its branches to infra-hyoid muscles, given off in carotid triangle) is derived from loop between 1st and 2nd cervical nerves.

Glosso-pharyngeal nerve, after its exit from the skull, passes forwards between int. jugular vein and int. carotid artery, and descends superficial to int. carotid, deep to ext. carotid and to styloid process and its muscles. At lower border of stylo-pharyngeus it turns round it and runs forwards, superficial to it and the stylo-hyoid lig., to lie between hyo-glossus and genio-glossus, where it breaks up into terminal branches which ascend to palatine tonsil, posterior third of dorsum of tongue, soft palate, pharyngo- and glosso-epiglottic folds, and ant. aspect of epiglottis. Before reaching the side of tongue it supplies stylo-pharyngeus and sends branches to pharynx.

Stylo-hyoid ligament extends downwards and forwards from tip of styloid process, and passes between hyo-glossus and genio-glossus to be attached to lesser horn of hyoid bone. It may be partially ossified, or it may contain muscular fibres.

Anterior Median Line of Neck

Superficial fascia varies in thickness, and fat is most plentiful in it underneath chin. It contains fibres of platysma decussating beneath the chin ; terminations of nervus cutaneus colli (transverse cervical) on each side ; and the anterior jugular vein of each side, a little lateral to median plane.

Anterior jugular vein begins by the union of some small veins below the chin, descends near median plane, pierces the superficial layer of deep fascia a little above manubrium, communicates with

its fellow by a transverse anastomosing branch, and turns laterally, deep to sterno-mastoid, to end in external jugular vein.

Deep fascia extends from mandible to manubrium, but is adherent to hyoid bone. Above manubrium it is split into two layers, which are attached to anterior and posterior aspects of manubrium, near upper border. Between these two layers are: (1) some fatty areolar tissue and sometimes a lymph gland; (2) the sternal head of sterno-mastoid and (3) anterior jugular vein, on each side; and crossing the median plane (4) the anastomosis between ant. jugular veins, (5) interclavicular ligament.

Deeper Structures — **Above hyoid bone**: — Anterior bellies of digastric diverge from each side of symphysis, and between them and hyoid bone is the submental triangle, in which lie a few lymph glands; they drain median part of lip and chin and anterior part of tongue. Bisecting the triangle in median plane is the fibrous raphe into which the mylo-hyoids are inserted; and just above hyoid bone is the anastomosis between hyoid branches of the lingual arteries of the two sides. A pin pushed dorsally on either side of median plane, just above hyoid bone, would pass through skin, fasciæ, mylo-hyoid, genio-hyoid, genio-glossus, mucous membrane of pharyngeal surface of tongue; and would appear in vallecula between tongue and epiglottis.

Below Hyoid Bone. — An elliptical or lozenge-shaped space is bounded on each side by sterno-hyoid above, sterno-thyroid below. Within the space are: (1) the *median thyreo-hyoid lig.* (median part of thyreo-hyoid membrane), crossed superficially by (2) anastomosis between *hyoid branches* of superior thyroid arteries; a pin pushed dorsally, just below hyoid bone, would pass through skin, fasciæ, median thyreo-hyoid ligament, a pad of fat, stem of epiglottis, and mucous membrane of laryngeal surface of epiglottis; would appear in vestibule of larynx, and would pass on into pharynx. (3) *Thyroid cartilage* with *prominentia laryngea* (Adam's apple) at its upper end. (4) *Crico-thyroid lig.* (median part of crico-thyroid membrane), crossed superficially by (5) anastomosis of *crico-thyroid arteries*; a pin pushed through the ligament enters cavity of larynx, some distance below pharyngeal vocales (true vocal cords); the ligament and crico-thyroid interval are very small in children. (6) Arch of *cricoid cartilage*, and on each side the *crico-thyroid muscle*. (7) *Crico-trachea ligament* and *first ring of trachea*. (8) *Isthmus of thyroid gland*, opposite 2nd, 3rd, 4th rings of trachea; along its upper border (9) an *anastomosis* between superior thyroid arteries, and from this border, on the left side, (10) the *pyramidal lobe* projects upwards and is connected by *levator glandulæ thyroideæ* to hyoid bone. (11) Lower cervical rings of *trachea*. (12) *Pretracheal fascia*, extending upwards to ensheath thyroid gland and to be attached to cricoid and thyroid cartilages, and downwards into thorax to be connected with pericardium. (13) *Inferior thyroid veins*, piercing pretracheal fascia and descending

anterior to it. (14) Remains of *thymus*, anterior to the veins. (15) *Innominate artery*, posterior to thymus, may still be anterior to trachea in root of neck; and the left innominate vein, although in the thorax, can be seen, anterior to the artery, in the dissection of root of neck.

MUSCLES OF THE HEAD

Facial muscles, or **muscles of expression**, include muscles of scalp, extrinsic muscles of the ear, muscles of eyelids, nose, and mouth. All are supplied by *facial nerve*.

MUSCLES OF SCALP

Epicranius (Occipito-frontalis).—Two flat fleshy bellies, on each side, connected by a flat intermediate tendon, which is continuous across top of scalp with its fellow of opposite side, forming *galea aponeurotica* (epicranial aponeurosis).

Occipital belly arises from lateral $\frac{3}{4}$ of superior nuchal (curved) line. **Frontal belly** (insertion) is mingled with orbicularis oculi and corrugator supercilii. It raises eyebrows, wrinkles skin of forehead, and may move skin of scalp backwards and forwards.

Galea aponeurotica is attached posteriorly between occipital bellies, to ext. occipital protuberance and highest nuchal lines; its lateral edges are firmly adherent to pericranium, and are continuous with a thin fascia which is superficial to the temporal fascia.

Extrinsic Muscles of Ear.—**Auricularis posterior** extends from mastoid process to cranial surface of auricle (pinna). **Auricularis superior** extends from temporal fascia and galea aponeurotica to top of root of auricle. **Auricularis anterior** extends from temporal fascia to top of root of auricle.

Scalp includes the area anterior to the nuchal lines and between temporal lines of the two sides. Over the vertex it consists of: (1) skin; (2) dense superficial fascia containing the vessels and nerves, and adherent to both skin and galea; (3) galea aponeurotica (epicranial aponeurosis); (4) loose areolar tissue; (5) periosteum, called here the pericranium. In frontal and occipital regions the galea is replaced by fleshy bellies of epicranius (occipito-frontalis), and superficial fascia is not so dense.

In the temporal region (beyond the scalp), the skull is covered by: (1) skin; (2) superficial fascia; (3) extrinsic muscles of ear and a thin fascia continuous with lateral expansions of galea; (4) temporal fascia; (5) temporal muscle; (6) periosteum.

Nerves of the Scalp.—Ten on each side: 4 sensory and 1 motor,

mainly anterior to auricle ; 4 sensory and 1 motor, mainly posterior to auricle. Anterior to auricle—*sensory* : supra-trochlear, supra-orbital, zygomatico-temporal, auriculo-temporal ; *motor* : temporal branches of facial. Posterior to auricle—*sensory* : great auricular, lesser occipital, greater occipital, smallest or third occipital ; *motor* : posterior auricular branch of facial.

Supra-trochlear nerve, a terminal of frontal branch of ophthalmic, emerges from orbit, $\frac{1}{2}$ inch from median plane, turns upwards, pierces frontalis muscle, and supplies skin of median part of forehead. **Supra-orbital nerve**, a terminal branch of frontal, emerges from orbit through supra-orbital notch, turns upwards, divides into *medial* and *lateral branches*, which pierce frontalis and galea aponeurotica, respectively, and supply skin as far back as vertex.

Zygomatico-temporal nerve (temporal of temporo-malar), a terminal of zygomatic branch of maxillary nerve, pierces temporal fascia a little posterior to zygomatic (malar) bone, or posterior to zygomatic (ext. angular) process of frontal, and supplies a small area of skin in anterior part of temporal region.

Auriculo-temporal nerve, a branch of mandibular nerve (inf. maxillary), ascends over posterior root of zygoma, immediately anterior to auricle, in company with superficial temporal artery ; gives branches to auricle, meatus, and tympanic membrane ; and divides into two branches which supply skin of side of head as far as vertex.

Temporal branches of facial nerve emerge from parotid gland, run upwards and anteriorly over zygomatic arch, and supply auricularis anterior and superior, frontalis, corrugator supercilii, and upper part of orbicularis oculi.

Great auricular nerve, from anterior branches (anterior primary divisions) of 2nd and 3rd cervical nerves, ascends on sterno-mastoid, pierces deep fascia, gives branches to face and lower part of auricle, and mastoid branches to skin in mastoid region, behind auricle.

Lesser occipital nerve, from anterior branch of 2nd cervical, ascends along post. border of sterno-mastoid, and then, on its surface ; pierces deep fascia, and gives branches to upper part of cranial surface of auricle, to skin over mastoid region and lateral part of occipital region.

Greater occipital nerve is the medial division of posterior branch (post. primary division) of 2nd cervical nerve. It turns upwards and medially, superficial to suboccipital triangle, pierces semispinalis capitis (complexus) and trapezius, near their attachments ; pierces deep fascia at sup. nuchal line, about 1 in. from ext. occipital protuberance ; supplies skin over occipital bone and post. part of parietal.

Third occipital nerve, the medial division of posterior branch of 3rd cervical nerve, pierces semispinalis capitis, trapezius, and deep fascia ; supplies skin of upper part of back of neck, and may supply skin of scalp above nuchal line, near median plane.

Posterior auricular nerve, a branch of facial, turns upwards

between mastoid process and external acoustic meatus, and is distributed to (1) intrinsic muscles of ear, (2) auricularis posterior (*retrahens*), and (3) occipital belly of *epicranius*.

All the nerves communicate with their neighbours on the scalp.

Arteries of the Scalp.—Five on each side, and they anastomose freely with each other and with those of opposite side: frontal, supra-orbital, superficial temporal, anterior to auricle; posterior auricular and occipital, posterior to auricle.

Frontal and supra-orbital arteries spring from ophthalmic branch of int. carotid, and accompany supra-trochlear and supra-orbital nerves, respectively.

Superficial temporal artery arises as a terminal branch of ext. carotid, posterior to neck of mandible; gives off parotid, anterior auricular, and transverse facial branches; ascends over post. root of zygoma, immediately anterior to auricle, in company with auriculo-temporal nerve; gives off middle temporal artery, which pierces temporal fascia, and sinks into temporal muscle (it may arise below zygoma); and finally the superficial temporal artery divides into frontal and parietal branches, which extend towards the frontal and parietal tuberosities (eminences), respectively, supplying constituents of scalp. The frontal branch is very tortuous, and can be seen pulsating.

Posterior auricular artery arises from ext. carotid, above the level of posterior belly of digastric; runs posteriorly and upwards upon styloid process, deeply placed under cover of parotid gland, giving parotid and muscular branches, and a stylo-mastoid branch, which enters stylo-mastoid foramen; then, becoming more superficial, it ascends between mastoid process and ext. meatus, with post. auricular nerve, and gives branches to sterno-mastoid, auricle, and scalp near the auricle.

Occipital artery arises from ext. carotid, below post. belly of digastric; leaves ant. triangle of neck (p. 220) under cover of sterno-mastoid and digastric; crosses rectus lateralis, which separates it from vertebral artery; runs posteriorly, upwards and medially, in a shallow groove on mastoid temporal, superficial to obliquus superior,—under cover of origin of posterior belly of digastric, mastoid process, longissimus capitis (*trachelo-mastoid*), splenius capitis, and sterno-mastoid. It leaves obliquus superior to lie upon semispinalis capitis (*complexus*); and, emerging from under cover of sterno-mastoid, it crosses apex of posterior triangle of neck, passes under cover of trapezius, and, turning upwards, it pierces trapezius and fascia, close to greater occipital nerve, and breaks up into branches which supply greater part of posterior region of scalp; one of these sends a branch through parietal foramen to the meninges. (While occipital artery lies on obliquus superior it sends a meningeal branch through mastoid foramen, and gives off unnamed muscular branches, and the *ramus descendens* (art. princeps cervicis), which runs downwards and medially, and divides into superficial and deep branches at lateral border of semispinalis capitis.)

Veins of scalp form a plexus drained by trunks which correspond to the arteries.

Frontal and supra-orbital veins drain the forehead, communicate with ophthalmic veins, and unite to form angular vein, *i.e.* the commencement of anterior facial vein. **Superficial temporal vein** drains temporal and adjoining parts of frontal and parietal regions; joins middle temporal above zygoma to form posterior facial, which descends in front of ear, with superficial temporal artery, into parotid gland.

Posterior auricular vein drains posterior parts of temporal and parietal regions; descends posterior to the ear, and ends below ear by joining ext. jugular. **Occipital vein** drains the occipital and posterior parietal regions; pierces trapezius, but, instead of accompanying occipital artery, it ends in the plexus in sub-occipital space, which is drained by vertebral and deep cervical veins.

Emissary vein which passes through parietal foramen connects superior sagittal sinus with veins of posterior parietal region; and the emissary vein which passes through mastoid foramen connects transverse (lateral) sinus with occipital vein.

Lymphatics of Scalp.—Those from *occipital region* end in **occipital glands**, which lie on occipital attachment of trapezius. Those from *posterior parts of parietal and temporal regions*, *i.e.* posterior to level of ear, end in **posterior auricular glands**, which lie on mastoid insertion of sterno-mastoid. Those from *anterior part of scalp* end in **anterior auricular glands**, which lie on surface of parotid gland.

Efferents from all these glands end in **superficial cervical glands**, which lie along ext. jugular vein, and in **upper deep cervical glands**, which lie along carotid sheath, down to level of thyroid cartilage.

MUSCLES OF EYELIDS

Orbicularis Oculi.—A sphincter lying in and around eyelids, in form of loops, *attached* medially to medial palpebral (tarsal) lig., medial angular process of frontal bone, frontal process of maxilla. No bony attachment laterally, but bundles *in* eyelids are connected with lateral tarsal ligament. *Pars lacrimalis* consists of a few fibres which spring from medial palpebral ligament, curve round the superficial aspect of lacrimal sac, and are inserted into lacrimal crest of lacrimal bone. Orbicularis closes eyelids and draws them medially; part in eyelids and part beyond eyelids can each act independently, *e.g.* to close the eyelids; to protect the eyes without closing eyelids. *Pars lacrimalis* compresses lacrimal sac.

Some fibres conveyed to orbicularis by facial nerve are said to arise in nucleus of oculo-motor.

Corrugator supercilii arises from medial end of superciliary arch,

and is inserted into skin of eyebrows. It produces vertical furrow in skin of middle of forehead.

Levator palpebræ superioris. See Muscles of Orbit, p. 236.

MUSCLES OF NOSE

Procerus (*pyramidalis nasi*), a prolongation from epicranius to aponeurosis of nasalis. Wrinkles skin of nose. **Nasalis** (*compressor naris*) arises from maxilla above incisor fossa and ends in aponeurosis, which joins its fellow on dorsum of nose. **Dilatores naris**: two small slips placed on lateral margin of nostril. **Depressor alæ nasi** extends from incisor fossa of maxilla to ala and septum of nose. **Caput angulare** of *quadratus labii superioris* (see below).

MUSCLES OF MOUTH

Orbicularis Oris.—A sphincter occupying lips, and continuous with muscles converging on mouth, which contribute largely to it. Its own proper fibres radiate from different points—septum of nose, incisor fossæ, mandible at sides of symphysis. It closes and purses lips. Various movements in the lips can be produced by contraction of different portions of the muscle. Some fibres conveyed to it by facial nerve are said to arise in nucleus of hypoglossal.

Quadratus Labii Superioris.—Three heads all mingling with orbicularis before insertion into skin. **Caput angulare** (*levator labii superioris alæque nasi*) arises from lower part of frontal process of maxilla, and is inserted into ala of nose as well as into lip. **Caput infra-orbitale** (*levator labii superioris*) arises from maxilla above infra-orbital foramen. **Caput zygomaticum** (*zygomaticus minor*) arises from zygomatic (malar) bone. **Caninus** (*levator anguli oris*) arises from maxilla below infra-orbital foramen; inserted into skin of angle of mouth, after mingling with orbicularis. **Zygomaticus** (major) arises from zygomatic (malar) part of zygomatic arch; inserted into orbicularis and skin of angle. **Risorius** may be inseparable from platysma; origin: fascia over masseter; insertion: orbicularis and skin of angle. **Triangularis** (*depressor anguli oris*); origin: oblique line of mandible; insertion: orbicularis, skin of angle. **Quadratus labii inferioris** (*depressor*); origin: front of body of mandible; insertion: orbicularis and skin of lower lip. **Mentalis** (*levator menti*) extends from incisor fossa of mandible to skin of chin.

Platysma arises from deep fascia covering deltoid and pectoralis major, ascends over clavicle, lies in superficial fascia on lower part of posterior triangle and upper part of ant. triangle; is inserted into body of mandible, skin of lower part of face and lips, mingling

with oral muscles. The most anterior fibres decussate with fellows, below chin.

Buccinator arises from pterygo-mandibular raphe and alveolar borders of maxilla and mandible, lateral to molar teeth. It mingles with other muscles at angle of mouth. Middle fibres decussate, upper ones descending to lower lip, lower ones ascending to upper lip. It flattens cheek against gums and teeth, and prevents food from accumulating in vestibule of mouth during mastication. Separated from masseter and temporal by suctorial pad of fat; pierced by parotid duct and twigs from buccinator branch of mandibular nerve. Ext. maxillary artery (facial), ant. facial vein, buccinator nerve and artery, buccal branches of facial nerve, zygomaticus, and risorius all lie on it.

MUSCLES OF MASTICATION

Supplied by mandibular division of trigeminal nerve.

Masseter lies on ramus of mandible; easily felt when jaws are clenched. **Origin** (fl.-tend.): superficial fibres directed downwards and posteriorly from ant. $\frac{2}{3}$ of lower border of zygomatic arch; deep fibres directed downwards and slightly anteriorly from whole of inner surface of zygomatic arch and post. $\frac{1}{3}$ of lower border. **Insertion** (fl.-tend.): outer surface of ramus, angle and coronoid process of mandible. **Nerve**: trigeminal, through masseteric branch. Raises mandible; superficial fibres also protrude, and deep fibres retract after protrusion.

Transverse facial vessels, parotid duct, branches of facial nerve lie on its lateral surface. Parotid gland overlaps it posteriorly. Ext. maxillary (facial) artery can be felt beating on mandible at its anterior border, and ant. facial vein is behind the artery.

Temporalis.—**Origin** (fl.): floor of temporal fossa; temporal fascia. **Insertion** (tend.-fl.): borders and inner surface of coronoid process; anterior border of ramus of mandible. **Nerves**: trigeminal, through deep temporal. Raises mandible; ant. fibres protrude, posterior retract.

On its upper part lie auricularis anterior, orbicularis oculi; superficial temporal vessels, auriculo-temporal, and temporal branches of facial nerve; temporal fascia. Its lower part is under cover of zygomatic arch and masseter. Buccinator nerve often pierces it.

Pterygoideus Externus.—Lies in infra-temporal fossa. **Origin**—(Upper head (fl.-tend.): infra-temporal ridge and

surface of great wing of sphenoid. *Lower head*: lateral surface of lateral pterygoid lamina. **Insertion** (tend.-fl.): anterior aspect of neck of mandible and of articular disc and capsule of mandibular joint. **Nerve**: trigeminal, through pterygoid branches. Protrudes mandible, and pushes it to opposite side.

Superficial to it are masseter, ramus and coronoid process of mandible, tendon of temporalis, internal maxillary artery, superficial head of pterygoideus internus. **Deep to it** are deep head of pter. int., mandibular nerve and its branches, mid. meningeal art., speno-mandibular lig., and often int. maxillary art. At upper border are masseteric and deep temporal nerves. At lower border appear lingual and inferior alveolar (dental) nerves. Buccinator nerve and int. maxillary artery pass between its two heads. It is surrounded by pterygoid plexus of veins.

Pterygoideus Internus.—Lies in infra-temporal fossa. **Origin.**—*Superficial head* (tend.): Small. Tuberosity of maxilla and lateral surface of pyramidal process of palatine. *Deep head* (fl.-tend.): Large. Medial surface of lateral pterygoid lamina, and surface of pyramidal process of palatine which appears in pterygoid fossa. **Insertion** (fl.-tend.): Inner surface of angle and ramus of mandible, posterior to mylo-hyoid groove. **Nerve**: trigeminal, through pterygoid branches. Elevates mandible; protrudes and pushes it to opposite side.

Superficial to it are ramus of mandible, pterygoideus externus, lingual and inf. alveolar (dental) nerves, internal maxillary and inf. alveolar vessels, speno-mandibular ligament. **Deep to it** are tensor and levator veli palatini, sup. constrictor; stylo-glossus, stylo-pharyngeus, tonsillar and asc. palatine branches of ext. maxillary (facial) art., and the loop of that artery itself; submaxillary gland; ext. carotid art., stylo-hyoid and post. belly of digastric at angle of mandible.

Deglutition

Voluntary Stage: 1. Breath drawn in and held. 2. Lips and cheeks usually, but not necessarily, pressed against teeth and gums by orbicularis oris and buccinator. 3. Jaws closed by masseters, temporals, internal pterygoids. 4. Tongue and hyoid bone slightly elevated by mylo-hyoids. 5. Tongue, hyoid bone, and larynx forcibly and suddenly raised, so that tongue is pressed against roof of mouth, and bolus of food is projected, through fauces, towards pharynx.

Tongue is raised by *mylo-hyoids*, *stylo-glossi*, assisted by glosso-palatini, and indirectly by elevators of hyoid. It is pulled backwards

as well as upwards; and it is thickened vertically by contraction of its intrinsic longitudinal and transverse fibres. Hyoid bone is raised by digastrics, stylo-hyoids, genio-hyoids, mylo-hyoids, hyo-glossi. Larynx is pulled up with hyoid, and also by stylo-pharyngei and pharyngo-palatini.

Involuntary Stage: 1. Glosso-palatini and pharyngo-palatini, in palatine arches (pillars of fauces), contract after the bolus has passed the glosso-palatini, to prevent bolus from returning to mouth, while pharyngo-palatini help to prevent it from passing up to nose. Pharyngo-palatine arches, thus drawn together, form an inclined plane under which the bolus slips downwards. 2. Pharynx is drawn up over advancing bolus by salpingo-pharyngei, stylo-pharyngei, pharyngo-palatini. 3. To shut off nose the soft palate is stretched and raised upwards and backwards, into contact with postero-superior wall of nasal pharynx, by tensores and levatores veli palatini. Uvula is shortened by uvular muscle and comes into contact with post. wall of pharynx; and posterior palatine arches, drawn together by pharyngo-palatini, completely close naso-pharyngeal isthmus. 4. To close opening into larynx:—Larynx is drawn up (see above). Arytenoid cartilages are drawn together by arytenoidi and crico-arytenoidi laterales, and drawn forwards from posterior wall of pharynx by vocales and thyreo arytenoidi. Ary-epiglottic folds are shortened and approximated by ary-epiglottici. Epiglottis is drawn slightly down and back by ary-epiglottici and thyreo-epiglottici, so that epiglottic tubercle (cushion) fits into angle formed by arytenoid cartilages and ary-epiglottic folds, completely closing aperture; and bolus glides over pharyngeal surfaces of epiglottis, ary-epiglottic folds, arytenoid cartilages and cricoid, into œsophagus. 5. Constrictors of pharynx seize bolus, and by successive contractions send it on to œsophagus. 6. Oesophagus by peristaltic contraction propels it to stomach.

From raising of tongue to contraction of constrictors the movements are so rapid that they are almost simultaneous.

FASCIA AND MUSCLES OF ORBIT

Fascia Bulbi Capsule of Tenon.—A loose sheath forming a socket for eyeball in its movements. Attached anteriorly to conjunctiva, close to margin of cornea; posteriorly to sheath of optic nerve. Ocular surface is smooth, and is connected with eyeball by soft areolar tissue.

It is pierced posteriorly by posterior ciliary vessels and nerves and vena vorticosæ, and anteriorly by anterior ciliary vessels, and opposite equator of eyeball by tendons of recti and obliqui. Apertures through which tendons pass are strengthened to form pulleys, except in case of obliquus superior; and, from lips of apertures, sheaths are reflected on to muscles and are lost on them, except that for obliquus sup.,

which becomes attached to trochlea, and that for obliquus inf., which is attached to floor of orbit, and limits action of that muscle. **Check ligaments**, connecting sheaths of rectus lateralis and medialis to zygomatic (malar) and lacrimal bones, respectively, restrain these muscles. Rectus superior is restrained by a connection with levator palpebræ; and rectus inferior by connection with suspensory lig. **Suspensory ligament** slings eyeball. It has pointed attachments to zygomatic and lacrimal bones, from which it widens out to fuse with fascia bulbi, below eyeball.

Levator palpebræ superioris lies immediately below roof of orbit. **Origin** (tend.): roof of orbit, anterior to optic foramen. **Insertion**: by three tendinous laminæ: one is attached to skin of upper eyelid after mingling with orbicularis oculi; another to upper edge of sup. tarsal plate; the third into fornix conjunctivæ, after blending with sheath of rectus superior. Edges of laminæ are connected with orbital margin to check movement. **Nerve**: oculo-motor, through superior branch.

Rectus superior, inferior, lateralis, medialis arise from tendinous ring surrounding optic foramen, lateralis by two heads, between which pass oculo-motor, abducent, naso-ciliary nerves, and ophthalmic vein. After piercing fascia bulbi each is **inserted** into sclera of eyeball, anterior to equator, three or four lines behind margin of cornea, the superior and inferior in a vertical plane, slightly medial to axis of eyeball, lateralis and medialis in a horizontal plane, medialis being attached nearer to cornea than the others. **Nerves**: lateralis by abducent (6th cerebral); superior by oculo-motor (3rd cerebral), through superior ramus; medialis and inferior by oculo-motor, through inferior ramus.

Obliquus superior lies under medial border of roof of orbit. **Arises** from tendinous ring, between rectus superior and medialis. Its tendon passes through fibrous ring or trochlea attached to anterior and medial part of roof of orbit, and is directed from there, laterally and posteriorly, below rectus superior, to be **inserted** into sclera, between rectus superior and lateralis, midway between margin of cornea and entrance of optic nerve. **Nerve**: trochlear (4th cerebral).

Obliquus inferior arises from orbital surface of maxilla, lateral to naso-lacrimal groove (fl.-tend.); is directed laterally and posteriorly, below eyeball and rectus inferior insertion, then upwards between eyeball and r. lateralis, to be **inserted** between r. lateralis and superior, a little posterior to level of insertion of obliquus sup. **Nerve**: oculo-motor, through ramus inferior.

Actions of Recti and Obliqui.—R. superior directs pupil upwards and medially. R. inferior directs pupil downwards and medially. R. lateralis directs pupil laterally. R. medialis directs pupil medially. O. superior directs pupil downwards and laterally.

O. inferior directs pupil upwards and laterally. R. mediales of opposite sides act in unison to converge eyes to focus on a near point. R. lateralis acts with R. medialis of opposite side in looking to one side. Direct downward movement is produced by inf. rectus and sup. oblique, and direct upward by sup. rectus and inf. oblique.

MUSCLES OF RESPIRATION

Intercostales. Eleven pairs on each side, occupying intercostal spaces. They are supplied by intercostal nerves; and they elevate ribs.

External intercostals lie in same plane as obliquus externus abdominis. Each **arises** from lower border of rib above. Its fibres are directed downwards and anteriorly to be **inserted** into upper border of rib below. It extends from tubercle of rib to junction of rib and cartilage, where it is continuous with **anterior intercostal membrane**, which extends to side of sternum.

Internal intercostals lie in same plane as obliquus internus abdominis, and those of lowest 2 spaces are continuous with it. Each **arises** from costal cartilage and upper margin of costal groove of rib above. Its fibres are directed downwards and posteriorly to upper border of rib below. It extends from side of sternum to angle of rib, where its border is free, except for a loose connection with retro-pleural connective tissue. Its inner surface is in contact with pleura, except in lower spaces where it is in contact with diaphragm. **Posterior intercostal membrane**, which replaces int. intercostal, is attached medially to ant. costo-transverse ligament, and laterally it slips in between ext. and int. intercostals and soon fades away.

Levatores Costarum.—12 pairs of small fan-shaped muscles, in series with ext. intercostals, **arising** by apices from transverse processes, from 7th cervical to 11th thoracic vertebra, and **inserted** into ribs, posterior to angles. **Nerves**: intercostals.

Subcostales.—Small slips found on inner surfaces of ribs near angles, in series with internal intercostals, but pass over several ribs.

Transversus thoracis (triangularis sterni) lies on posterior surfaces of sternum and costal cartilages, in same plane as transversus abdominis. **Origin** (tl.-tend.) xiphoid process and lower 3 segments of body of sternum. **Insertion** 6th, 5th, 4th, 3rd, 2nd costal cartilages, close to junction with ribs. **Nerves**: corresponding intercostals. It separates int. mammary vessels from pleura. It depresses costal cartilages.

Diaphragma.—The diaphragm is the arched musculo-tendinous partition between thorax and abdomen. Consists of a circumferential fleshy part, whose fibres converge, in an upward direction, upon the **centrum tendineum**—a tendinous central part, which is composed of right, left and intermediate lobes, resembling a trefoil leaf, and is regarded as the **insertion**. **Origin**: dorsal aspect of xiphoid process, by 2 fleshy slips; inner surfaces of lower 6 costal cartilages, by fleshy slips, interdigitating with transversus abdominis; lateral and medial lumbo-costal arches; bodies of upper 3 lumbar vertebræ, by two crura; median arcuate ligament.

Arcus lumbo-costalis lateralis (ext. arcuate lig.), a thickening of ant. lamella of lumbo-dorsal fascia, arches across anterior surface of quadratus lumborum, from last rib to 1st lumbar transverse process. **Arcus lumbo-costalis medialis** (int. arcuate lig.), a thickening of fascia of psoas, arches across anterior surface of psoas, from 1st lumbar transverse process to body of 2nd lumbar vertebra and tendinous part of crus. **Crura** are elongated bundles, fleshy above, tendinous below, attached, the *right* to bodies of upper 3 lumbar vertebræ, the *left* to upper 2 only. Fibres are directed upwards, decussate anterior to aorta, encircle œsophagus, decussate again, before joining tendinous centre. **Median arcuate ligament**, a tendinous arch connecting the crura, anterior to aorta, gives origin to fibres which mingle with decussating fibres of crura.

Nerves: C. 3, 4, 5, through phrenic; diaphragmatic plexus of sympathetic; possibly lower intercostals.

Action: When muscular part contracts it descends, pushing abdominal viscera downwards and increasing capacity of thorax, so that lungs expand (see also p. 96).

Relations of Diaphragm.—**Abdominal surface**: Liver occupies a great part of abdominal surface, especially on right side. Stomach is in relation to the left and anteriorly; spleen, to the left and posteriorly. Kidney of each side lies against crus and part arising from lumbo-costal arches (arcuate lig.). Suprarenal gland lies on crus; celiac (semilunar) ganglion is medial to suprarenal. Pancreas lies across crura. Inferior vena cava lies on right crus.

Between the Crura.—Aorta, the cisterna (receptaculum) chyli, vena azygos, in that order from left to right, the vein being behind right crus rather than between crura.

Thoracic Surface.—Pericardium and heart are related to intermediate area; pleura, lung, and phrenico-pleural lig. are related to lateral area, on each side. A considerable circumferential area,

beyond pleura and phrenico-pleural lig., is in contact, antero-laterally, with costal cartilages, ribs and internal intercostal muscles; posteriorly, with upper ends of quadratus lumborum and psoas, above the level of lumbo-costal arches.

Besides these, there are various vessels and nerves and small portions of organs in relation to diaphragm. **Abdominal surface:** Duodenum, left colic (splenic) flexure, upper end of descending colon, and, sometimes, upper end of ascending colon. Left renal vessels, right renal artery, middle suprarenal arteries, inferior phrenic vessels, musculo-phrenic vessels, hepatic and left gastric (coronary) arteries, coronary vein, splenic vessels, coeliac plexus.

Posterior to each crus are upper 2 lumbar arteries, while vena azygos is behind right crus.

Thoracic surface: Thoracic aorta, oesophagus, vena azygos, vena hemi-azygos (v. az. minor inferior), splanchnic nerves, sympathetic trunks, last thoracic nerves and subcostal vessels.

Openings in Diaphragm.—**Hiatus aorticus:** between crura, dorsal to median arcuate ligament, opposite fibro-cartilage between last thoracic and first lumbar vertebrae. *Transmits* aorta, thoracic duct, vena azygos (major), two descending lymphatic trunks from intercostal glands. **Hiatus oesophageus:** dorsal to intermediate lobe of central tendon, amidst fibres of crura, opposite 7th costal cartilage and 10th thoracic vertebra, 1 inch to left of median plane. *Transmits* oesophagus, vagi, anastomosing oesophageal branches of left gastric (coronary) artery and of thoracic aorta. **Foramen venæ cavæ:** between dorsal parts of right and intermediate lobes of central tendon, opposite 8th thoracic vertebra. *Transmits* vena cava inferior, branches of right phrenic nerve, a few lymphatics from liver.

A gap exists between attachments to xiphoid and 7th cartilage, and there peritoneum and pleura are separated by areolar tissue only. Another gap sometimes exists between fibres attached to 12th cartilage and those from lumbo-costal arch, or between fibres from lateral and medial arches, kidney is there separated from pleura by fat and areolar tissue only.

Smaller Structures passing between Thorax and Abdomen.
—Sup. epigastric vessels pass between slips from xiphoid and 7th cartilage. Musculo-phrenic vessels, between slips from 7th and 8th cartilages. Lower five intercostal nerves, accompanied by vessels, between slips from 7th down to 12th cartilage. Last thoracic nerve and subcostal vessels, dorsal to lateral lumbo-costal arch. Sympathetic trunk, dorsal to medial lumbo-costal arch. Greater, lesser and lowest splanchnic nerves pierce crus. Vena hemiazygos (v. azygos minor inferior) pierces left crus.

FASCIÆ AND MUSCLES OF ABDOMINAL WALLS

Superficial fascia contains lateral cutaneous and terminal branches of lower intercostal nerves, and small vessels. In lower part of ant. abdominal wall and proximal part of front of thigh it consists of two layers, with superficial vessels and lymph glands between them. **Fatty superficial layer** is continuous with superficial fascia over rest of body; is devoid of fat over penis; fat is replaced by dartos muscle in scrotum.

Deeper membranous layer fuses above with superficial layer. Inferiorly, it is carried down over penis, fusing with superficial layer, and over spermatic cords to scrotum, where it fuses with superficial layer. Behind scrotum it is continuous with similar deep layer in perineum. Continuous line of attachment below, including that of layer in perineum, is to (1) base of fascia inferior of diaphragma urogenitale (triangular ligament); (2) margins of pubic arch; (3) deep fascia covering gracilis and adductor longus, on femoral aspect of pubis; (4) medial half of inguinal ligament (Poupart), or deep fascia just below it; (5) fascia lata a little distal to lateral half of inguinal ligament. These attachments prevent passage of extravasated urine backwards into ischio-rectal fossa, or distally into thigh. In median plane it is connected to linea alba, front of symphysis pubis, raphe of bulbo-cavernosus (ejaculator urinæ); and sends an incomplete septum into scrotum.

Deep fascia, very thin, covers obliquus externus; fuses with its aponeurosis anteriorly, with fascia lumbo-dorsalis posteriorly. **Fascia transversalis** is fascial lining of internal surface of ant. abdominal wall. Covers internal surface of transversus abdominis, and is separated from peritoneum by thin layer of extra-peritoneal areolar fatty tissue. *Anteriorly* it is continuous with fascia of opposite side. *Posteriorly* it is continuous with fascia of quadratus lumborum. *Superiorly* it joins fascia covering diaphragm. *Inferiorly* it is continuous with fascia iliaca, along crest of ilium and lateral half of inguinal ligament; anterior to femoral vessels it is carried distally, into thigh, as anterior wall of femoral sheath, and medial to that it is attached to pecten and crest of pubis. It is prolonged over spermatic cord and testis as **infundibuliform fascia** from margins of *abdominal inguinal ring* (p. 245).

Fascia Iliaca.—A thin fascia covering psoas and iliacus, and prolonged into thigh as posterior wall of femoral sheath. *Fascia covering quadratus lumborum.* See Fascia Lumbo-dorsalis, p. 191.

Linea Alba.—A band, $\frac{1}{2}$ inch broad above umbilicus, but narrow below it where recti are in apposition. Extends from xiphoid process to pubis. Formed by interlacing insertions of

aponeuroses of obliqui and transversi abdominis. Pierced in fœtus by **umbilicus**, which remains in adult as puckered cicatrix, and around it the fibrous tissue is very dense.

Linea semilunaris is a depression on the surface, extending from pubic tubercle to 9th costal cartilage, and corresponds to lateral border of rectus abdominis.

Rectus abdominis lies at side of linea alba, enclosed in sheath composed of aponeuroses of obliqui and transversus. **Origin** (tend.): crest of pubis and ant. lig. of symphysis. **Insertion** (fl.): anterior surfaces of xiphoid process and 7th, 6th, 5th costal cartilages. **Nerves**: lower 6 intercostals. Retracts abdominal wall; flexes vertebral column.

Substance is traversed by 3 tendinous intersections—*inscriptiones tendineæ*,—one opposite umbilicus, another opposite xiphoid, a third between these; fused with ant. wall of sheath, but not with post. wall.

Pyramidalis may be very small or absent. **Origin** (fl.): crest of pubis, anterior to rectus. **Insertion** (tend.): linea alba below umbilicus. **Nerve**: last thoracic. Tightens linea alba.

Obliquus externus abdominis lies superficially in antero-lateral wall of abdomen. **Origin** (fl.): lower 8 ribs, interdigitating with serratus anterior and latissimus dorsi. Fibres are directed downwards, anteriorly and medially. Its posterior border is free, and is overlapped above by latissimus dorsi. **Insertion**: by *fleshy fibres* into ant. $\frac{1}{3}$ of external lip of iliac crest; by broad *aponeurosis* into xiphoid process, linea alba, symphysis, crest, tubercle and pecten (pectineal line) of pubis. Some lower fibres traverse linea alba, and form triangular band called **lig. inguinale reflexum**, which is attached to crest, tubercle and pectineal line of opposite pubis, posterior to obliquus ext. of that side. **Nerves**: lower 6 intercostals. Obliqui and transversus all retract abdominal wall and flex vertebral column.

Lower border of aponeurosis of obliquus externus is thickened and curved backwards, so that it is grooved along its abdominal surface; and it is called **lig. inguinale**.

Ligamentum inguinale (Poupart's ligament) forms boundary line between ant. abdominal wall and front of thigh. **Connections**: It is attached laterally to anterior superior spine of ilium, medially to pubic tubercle, and, by an expansion called **lig. lacunare**, to pecten pubis (pectineal line) for $\frac{3}{4}$ -1 inch. Fascia lata is attached to its convex

lower margin. *Obliquus internus* arises from lateral $\frac{2}{3}$ of groove on its abdominal surface, and *transversus* from lateral $\frac{1}{3}$, posterior to *obliquus internus*.

Relations.—Muscles.—*Obliquus internus* and *transversus*, as above. *Iliacus*, *psaos major* and *pectineus* occupy greater part of space between lig. inguinale and hip bone, in that order from lateral to medial side. Fascia transversalis and fascia iliaca become continuous with one another along lateral part of the ligament, in relation to *iliacus*; but more medially they are continued around the femoral vessels, as femoral sheath.

Vessels.—*External iliac artery* becomes femoral art. between lig. inguinale and *psaos*, midway between symphysis pubis and anterior superior iliac spine, *i.e.* about $\frac{1}{2}$ inch medial to midpoint of lig. inguinale. *Femoral vein* becomes ext. iliac, on medial side of artery, between lig. inguinale and contiguous margins of *psaos* and *pectineus*; and the *femoral ring* is medial to the vein, between lig. inguinale and *pectineus*.

Superficial circumflex iliac artery runs laterally, towards ant. sup. iliac spine, below lig. inguinale, and sends small branches upwards over it. *Superficial epigastric artery* ascends over ligament to ant. abdominal wall. *Superficial external pudendal artery* runs medially toward penis and scrotum below the ligament, and sends small branches upwards over it.

Inferior epigastric artery arises from ext. iliac just above the ligament, but sends its pubic, or its "abnormal obturator" branch, downwards and medially, posterior to the ligament. *Deep circumflex iliac artery* arises from ext. iliac, and runs laterally, posterior to the ligament, between transversalis fascia and peritoneum.

Internal spermatic and *external spermatic* (cremasteric) are above medial end of ligament, in spermatic cord.

All these arteries are accompanied by *veins*.

Nerves.—*Lateral cutaneous nerve* of thigh passes out of abdomen between the ligament and *iliacus*, close to ant. sup. iliac spine; *femoral nerve* (ant. crural), in groove between *iliacus* and *psaos*; *lumbo-inguinal nerve* (crural branch of genito-crural), in lateral wall of femoral sheath. *Ilio-inguinal nerve* passes through subcutaneous inguinal ring, above medial end of the ligament. *Ext. spermatic nerve* (genital branch of genito-crural) and sympathetic *spermatic plexus* are above its medial end, in the spermatic cord.

Viscera.—A few *inguinal lymph glands* lie in superficial fascia just above the ligament; the upper *superficial subinguinal lymph glands* lie in superficial fascia just below the ligament, and their afferents from ant. abdominal wall descend over the ligament.

Medial part of groove on abdominal surface of lig. inguinale, and the abdominal surface of lig. lacunare (Gimbernat) form the floor of inguinal canal, and support *spermatic cord* and its infundibuliform

and cremasteric coverings; and medial end of lig. inguinale forms infero-medial part of inferior crus of subcutaneous ring (ext. abdominal), and the cord lies on this part of the crus as it emerges through the ring.

Lateral half of lig. inguinale is related to *cæcum* on the right side, *iliac colon* on the left side, peritoneum and transversalis fascia intervening in both cases.

Ligamentum lacunare (Gimbernat's lig.) is the expanded part of medial end of lig. inguinale. It is triangular in shape. **Apex** is attached to pubic tubercle. **Posterior border** is attached to pecten pubis (pectineal line) for $\frac{3}{4}$ -1 inch, in front of falx inguinalis (conjoint tendon) and of lig. reflexum (triangular fascia), with which its fibres are continuous. **Anterior border** is continuous with lig. inguinale. **Base** is free, directed laterally, and forms medial boundary of femoral (crural) ring. *Abdominal surface* supports spermatic cord. Pectineus and superior horn of falciform margin of fossa ovalis (saphenous opening) are attached to *femoral surface*.

Subcutaneous inguinal ring (p. 245) is a triangular aperture in aponeurosis of obliquus externus, above pubic tubercle (spine) and medial end of lig. inguinale. From its margins the **external spermatic fascia** is prolonged over spermatic cord and testis.

Obliquus internus abdominis lies deep to obliquus externus. **Origin** (tl.): lumbo-dorsal fascia, ant. $\frac{2}{3}$ of iliac crest, lateral $\frac{3}{4}$ of lig. inguinale (Poupart). Fibres are directed mainly upwards and anteriorly; upper or posterior fibres are nearly vertical; lower fibres are horizontal, the lowest being bent downwards. **Insertion**: posterior part by *fleshy fibres* into last 3 ribs and costal cartilages. Remainder by broad *aponeurosis* into cartilages of 9th, 8th, 7th ribs: whole length of linea alba: crest and pecten (pectineal line) of pubis. **Nerves**: lower intercostals; last thoracic; 1st lumbar, through ilio-hypogastric and ilio-inguinal.

Aponeurosis, from a point midway between umbilicus and symphysis up to rib margin, splits at linea semilunaris into 2 laminae, which enclose rectus. Aponeurosis of the part arising from lig. inguinale does not split, but passes wholly in front of rectus, joining with part of transversus having corresponding origin, to form falx inguinalis (conjoint tendon). Lowest fleshy fibres run medially in front of spermatic cord, and, becoming aponeurotic, arch downwards in the falx, behind cord. Cord, as it passes below this

arched lower border of obliquus internus, receives a covering of loops of muscle, held together by fascia called **cremasteric fascia**.

Cremasteric Muscle.—A series of loops descending over spermatic cord and testis, one end of loop being attached with lowest fibres of obliquus internus to lig. inguinale, the other to pubic tubercle (spine). **Nerve**: L. 1, 2, through external spermatic (genital branch of genito-crural). Draws up testis.

Transversus abdominis.—Deepest muscle in antero-lateral wall of abdomen. **Origin** (fl.): inner surfaces of lower 6 costal cartilages, interdigitating with diaphragm; lumbo-dorsal fascia; anterior $\frac{2}{3}$ of internal lip of iliac crest; lateral $\frac{1}{3}$ of lig. inguinale. Fibres are directed horizontally medially, except lower ones, which pass medially and then turn downwards. **Insertion**: by aponeurosis into whole length of linea alba, and into crest and pecten (pectineal line) of pubis. **Nerves**: lower 6 intercostals, last thoracic, 1st lumbar through ilio-hypogastric and ilio-inguinal.

Aponeurosis passes posterior to rectus, from a point midway between umbilicus and pubis upwards; anterior to rectus below that point. Part arising from lig. inguinale is above level of spermatic cord, but its aponeurosis joins corresponding part of obliquus internus and passes down behind cord.

Falx aponeurotica inguinalis (conjoint tendon), composed of fused aponeuroses of parts of obliquus internus and transversus arising from lig. inguinale (Poupart). Directed medially and downwards, posterior to spermatic cord laterally, anterior to rectus medially. Attached to linea alba medially, to crest and pecten (pectineal line) of pubis inferiorly, behind lig. reflexum and obliquus externus.

Vagina m. recti abdominis (Sheath of rectus) is complete from rib margin down to midway between umbilicus and pubis. **Anterior wall**: aponeurosis of obliquus ext., anterior lamina of obl. int. **Posterior wall**: aponeurosis of transversus, posterior lamina of obl. int.; at its upper end aponeurosis of transversus is so narrow that uppermost fleshy fibres of transversus are found in post. wall of sheath.

For some distance above pubis the posterior wall is absent; all three aponeuroses are anterior to rectus, which lies directly on fascia transversalis. At lower part of abdomen the ext. oblique aponeurosis does not fuse with the others till near median plane. *Linea semicircularis* is crescentic lower edge of posterior wall, and inf. epigastric vessels enter sheath in front of it. This edge is not wholly free, except by dissection; a thin stratum is continued downwards from it for some distance, and probably consists of some fibres

of transversus which have not passed in front of rectus. Posterior wall of sheath ends superiorly at rib margin, and sup. epigastric vessels enter sheath in front of upper end. Above that, the rectus lies on costal cartilages and is covered by aponeurosis of obl. ext. alone. **Contents of sheath:** rectus abdominis, pyramidalis, superior and inferior (deep) epigastric vessels: terminal parts of lower 6 intercostal and last thoracic nerves, with accompanying vessels; they enter sheath by piercing its lateral margin.

Canalis Inguinalis.—A passage, $1\frac{1}{2}$ inch long, situated above medial half of inguinal ligament (Poupart), among muscles, aponeuroses and fascia of lower part of anterior abdominal wall, for transmission of spermatic cord in male, ligamentum teres uteri in female. It is directed medially, downwards, and forwards. Its ends are called inguinal rings:

Annulus Inguinalis Abdominalis (Internal Abdominal Ring).—An oval aperture in fascia transversalis, long axis vertical, $\frac{1}{2}$ inch long, situated $\frac{1}{2}$ inch above inguinal lig. (Poupart), midway between symphysis pubis and ant. sup. iliac spine (cf. Femoral Artery). Its margins are prolonged over spermatic cord and testis as *infundibuliform* or *internal spermatic fascia*. Peritoneum covering it is puckered and may pass a little way through it into canal, and is connected with shrivelled fibrous remnant of the proximal part of the fetal peritoneal prolongation into scrotum, called processus vaginalis. Inferior epigastric vessels lie below and medial to it, and an indirect inguinal hernia enters canal through abdominal ring, on lateral side of vessels. It *transmits* fibrous remnant of processus vaginalis, external spermatic (cremasteric) vessels, external spermatic nerve (genital branch of genito-crural n.), and constituents proper of spermatic cord, namely, ductus deferens, int. spermatic artery, pampiniform plexus of veins, testicular lymphatics and sympathetic nerves.

Annulus Inguinalis Subcutaneus (Ext. Abdominal Ring).—An aperture in aponeurosis of obliquus externus, immediately above pubic tubercle (spine) and medial end of inguinal lig. (Poupart). $\frac{1}{2}$ to 1 inch long, smaller in female; triangular or lanceolate in shape, long axis and apex directed upwards and laterally, base formed by lateral part of pubic crest. Margins are called crura and are sewn together by diagonal fibres called *fibre intercrurales*: **external spermatic fascia**, a tubular covering of spermatic cord and testis, is continuous with the margins and with these fibres. **Superior crus** is straight. **Inferior crus** is curved; its lower or medial part is coincident with inguinal lig. and supports spermatic cord. Ring *transmits* structures transmitted by abdominal ring, and in addition: (1) infundibuliform fascia, derived from fascia transversalis at margins of abdominal ring, (2) cremasteric muscle and fascia, derived from lower border of obliquus int. —all surrounding spermatic cord; (3) termination of ilio inguinal nerve.

Anterior wall of inguinal canal: aponeurosis of obliquus ext. in all the length of canal; lowest fleshy fibres of obliquus int. in lateral half, behind obliquus ext. **Posterior wall:** fascia transversalis in all the length of canal; falx inguinalis (conjoint tendon) in medial half, in front of f. transversalis; lig. reflexum (triangular fascia), when present, in medial third or fourth, in front of falx. **Roof:** arched lower border of obliquus internus (and lower border of transversus). **Floor:** lig. inguinale (Poupart) (separating spermatic cord from femoral canal), and lig. lacunare (Gimbernat).

Contents: structures transmitted by the rings.

Triangle of Hesselbach.—**Bounded** medially by rectus abdominis, laterally by inf. epigastric vess., inferiorly by inguinal ligament. **Floor:** fascia transversalis, with falx inguinalis anterior to it in medial part. Inguinal canal is opposite lower part of triangle. A direct inguinal hernia enters inguinal canal on medial side of epigastric vessels, pushing floor of triangle before it.

Trigonum Lumbale (Petit).—Not always present. **Bounded** by latissimus dorsi posteriorly, obliquus ext. anteriorly, crest of ilium inferiorly. **Floor:** obliquus int. A lumbar abscess or hernia may come through it.

Ilio-psoas and Psoas minor. See Muscles of Lower Limb, p. 162.

Quadratus lumborum lies in posterior wall of abdomen, enclosed between ant. and middle layers of lumbo-dorsal fascia. Sacro-spinalis is posterior to it, psoas major anterior to it, medially. **Origin** (fl.-tend.): ilio-lumbar ligament; crest of ilium, posterior and lateral to lig.; lower lumbar transverse processes. **Insertion** (fl.-tend.): medial $\frac{1}{2}$ of lower border of last rib, upper lumbar transverse processes. **Nerves:** L. 1, 2, 3, 4, directly. Fixes last rib in respiration. Extends vertebral column and bends it laterally.

FASCIÆ AND MUSCLES OF PERINÆUM

Superficial fascia consists, *in posterior part*, of two pads of fibrous and fatty tissue filling up ischio-rectal fossæ; *in anterior part*, of two layers, a superficial fatty, a deeper membranous, described with fascia of abdomen (p. 240).

Deep fascia, posteriorly, lines ischio-rectal fossa, covering levator ani medially (anal fascia), and obturator internus laterally (obturator fascia). Anteriorly, it provides a delicate covering for superficial perineal muscles, but is strongly developed in connection with both upper and lower surfaces of deeper muscles—sphincter urethræ and transversus profundus,—which form the urogenital diaphragm.

Fascia inferior of urogenital diaphragm (Lower layer of triangular lig.).—Triangular. Truncated *apex* is thickened, and fused with anterior margin of fascia superior to form **transverse ligament of pelvis**, which is separated from arcuate pubic lig. (sub-pubic) by an oval aperture, transmitting deep dorsal vein of penis to pudendal (prostatic) plexus. Its *sides* are attached to the sides of pubic arch. Its *base* is fused with fascia superior and with deep, membranous layer of superficial fascia.

It is **pierced** at its **base** by internal pudendal artery and dorsal nerve of penis and perineal vessels and nerves; at each **margin** by internal pudendal artery and dorsal nerve of penis again; near its **centre** by urethra, ducts of bulbo-urethral (Cowper's) glands, and arteries to bulb; and, in female, by vagina and urethra. It is **covered** by structures lying in superficial perineal pouch, between it and deep layer of superficial fascia: Superficial muscles and vessels and nerves of perinæum; and *in male*, bulb and crura of penis, *in female*, crura of clitoris, bulb of vestibule and vestibular glands (Bartholin).

Fascia superior of urogenital diaphragm is connected *laterally* with sides of pubic arch and fascia over obturator internus, *anteriorly* and *posteriorly* with fascia inferior, *superiorly* with fascial sheath of prostate, which rests on it. It is pierced by urethra in male, by vagina and urethra in female. **Between the two fasciæ** are the membranous part of urethra, its sphincter, transversus profundus, bulbo-urethral (Cowper's) glands, internal pudendal arteries and arteries to bulb, a plexus of veins, dorsal nerves of penis.

Superficial Muscles of Perinæum. (1) *Corrugator cutis ani*—a few subcutaneous, unstriped fibres radiating from margin of anus. (2) *Sphincter ani externus* surrounds anus and lower part of anal canal. (3) *Transversus perinei superficialis*, on each side of median plane, lies superficial to base of fascia of urogenital diaphragm. (4) *Bulbo-cavernosus*, in male, covers proximal part of corpus cavernosum urethræ and its bulb, on each side of median plane; in female, it surrounds orifice of vagina. (5) *Ischio-cavernosus* covers crus of penis or clitoris.

Diaphragma urogenitale consists of *transversus perinei profundus* and *sphincter urethræ*, which lie in relation to membranous part of urethra, enclosed between two layers of fascia.

Central point of perinæum is situated $\frac{1}{2}$ inch anterior to anus, at base of fascia inferior of urogenital diaphragm, in median plane, at that point there is a fibro-muscular nodule formed by perineal muscles which converge upon it.

Sphincter ani externus.—Superficial fibres pass from tip to coccyx, around anus, to central point of perinæum. Deep fibres encircle anal canal, superficial to internal sphincter. Fibres of the two sides are continuous with each other posteriorly, mingle with other muscles at central point of perinæum anteriorly, with levator ani superiorly. **Nerves:** s. 2, 3, 4, through inf. hæmorrhoidal branch of pudendal and perineal branch of s. 4.

Sphincter ani internus surrounds anal canal under cover of mucous membrane. It is a thickening of circular fibres of gut.

Transversus perinæi superficialis arises from ramus of ischium, near tuber ischii, and runs medially to central point of perinæum. **Nerve:** s. 2, 3, 4, through perineal branch of pudendal.

Bulbo-cavernosus.—*In male* (ejaculator urinæ): **Origin:** central point of perinæum, median raphe on lower surface of bulb and corpus cavernosum urethræ. **Insertion:** from behind forwards, into fascia inf. of urogenital diaphragm, dorsum of corpus cav. urethræ, fascia on dorsum of penis. *In female* (sphincter vaginæ): **arises** from central point, surrounds orifice of vagina, covers bulb of vestibule; **inserted** into root and dorsum of clitoris. **Nerve:** same as transversus.

Ischio-cavernosus (Erector penis in male, E. clitoridis in female) arises from tuber and ramus of ischium; **inserted** into sides and lower surface of crus penis vel clitoridis. **Nerve:** same as transversus.

Transversus perinæi profundus arises by pointed tendon from junction of ischial and pubic rami; passes medially and expands to be **inserted** into median raphe, below and posterior to membranous urethra. **Sphincter urethræ membranaceæ** lies anterior to transversus. Its internal fibres surround urethra and are continuous above with muscular fibres of prostate. Its external fibres are continuous with anterior border of transversus profundus. They **arise** from pubic ramus and blend with those of opposite side, in front of and behind membranous urethra. **Nerves:** s. 2, 3, 4, through perineal branch of pudendal.

MUSCLES AND FASCIÆ OF PELVIS

Piriformis and Obturator Internus. See p. 171.

Diaphragma pelvis consists of levatores ani and coccygei.

Levator ani separates cavity of pelvis from ischio-rectal fossa. **Origin** (fl.): pelvic surface of body of pubis, obturator fascia, spine of ischium. **Insertion** (fl.): (1) Central point of perinæum; (2) side of anal canal between external and internal sphincters; (3) ano-coccygeal raphe or body—a fibro-muscular nodule between tip of coccyx and anus; (4) lower pieces of coccyx. **Nerves:** s. 2, 3, 4, through perineal branch of pudendal, and from s. 3, 4, directly. It

constricts lower end of rectum and increases angle between it and anal canal. Draws anus up over fecal mass at termination of defecation, and inverts anus, assisting sphincter to close it. Raises pelvic floor, *e.g.* in forced expiration.

Pelvic surface is in relation to pelvic viscera; perineal surface forms medial wall of ischio-rectal fossa. Triangular interval between anterior borders is occupied by prostate and urethra in male, vagina and urethra in female. These anterior fibres of the two sides embrace prostate, forming *levator prostatae* in the male; and form a second sphincter for vagina in the female. Posterior margin lies edge to edge with, or overlaps, coccygeus.

Coccygeus is fused with pelvic surface of lig. sacro-spinosum (small sacro-sciatic). **Origin** (tend.): spine of ischium. **Insertion** (il.-tend.): lowest piece of sacrum, 1st piece of coccyx. **Nerves**: s. 3, 4, directly. Raises pelvic floor, flexes coccyx.

Parietal pelvic fascia is (1) the fascia covering piriformis, obturator internus, coccygeus, and (2) the fascia superior of urogenital diaphragm, covering pelvic surfaces of sphincter (compressor) urethrae and transversus perinaei profundus. Obturator fascia is divided at origin of levator ani into pelvic part above, and perineal part below. Perineal part lines lateral wall of ischio-rectal fossa.

Fascia diaphragmatis pelvis inferior (anal fascia) covers perineal surface of levator ani, and is connected laterally with obturator fascia.

Fascia diaphragmatis pelvis superior covers pelvic surface of levator ani. It is connected antero-laterally with pubis and obturator fascia, posteriorly with coccygeus fascia, medially with fascia in which pelvic viscera are imbedded and ensheathed.

Ligamentum pubo-prostaticum vel pubo-vesicale medium, a band of fascia, thin in median plane, thickened on each side, extending from pelvic surfaces of pubes, at symphysis, to junction of prostate with neck of bladder. **Lig. pubo-vesicale laterale**, continuous with lig. medium, is the adjoining part of fascia diaphragmatis pelvis superior, and is also connected with prostate and bladder.

Fascia ensheathing viscera receives different names according to situation: prostatic, vesical, rectal, recto-vesical or recto-vaginal.

The student is expressly advised not to burden his memory with any detailed account of the pelvic fascia: even if he can understand it.

Cavum Retzii.—A space containing fat and areolar tissue between bladder and ant. pelvic wall, extending on each side as far as hypogastric artery (internal iliac) and its visceral branches; extending upwards to umbilicus between peritoneum and abdominal walls, where it is bounded laterally by obliterated umbilical arteries; limited below by pubo-prostatic lig. and fascia sup. of pelvic diaphragm.

Fossa Ischio-rectalis.—*Bounded above*, $2\frac{1}{2}$ inches from surface, by junction of fascia inferior of pelvic diaphragm (anal fascia) with obturator fascia: highest point is posterior, near

ischial spine; *medially*, by sphincter ani ext. and levator ani, with its fascia inferior of pelvic diaphragm; *laterally*, by ischium, obturator internus and its fascia, and falciform process of sacro-tuberos (great sacro-sciatic) lig.; *anteriorly*, by junction of deep layer of superficial fascia with the fasciæ of urogenital diaphragm (triangular lig.); *posteriorly*, by glutæus maximus and sacro-tuberos ligament.

Contents: pad of fat, intersected by fibrous tissue, and crossed, latero-medially, by inf. hæmorrhoidal vessels and nerves. Perineal branch of 4th sacral n. lies near posterior angle. Perforating cutaneous branch of 2nd and 3rd sacral nerves, and gluteal branches of posterior cutaneous n. (small sciatic), accompanied by branches of inf. gluteal (sciatic) vessels, turn round lower border of glutæus maximus. Perineal division of pudendal n. or its scrotal branches pass out of fossa at its anterior part.

Alcock's canal, on lateral wall of ischio-rectal fossa, about $1\frac{1}{2}$ inches from lower margin of tuber ischii, is formed by splitting of obturator fascia; contains dorsal nerve of penis, internal pudendal vessels, perineal division of pudendal nerve, in that order from above downwards.

Pelvic Floor consists of levatores ani and coccygei. **Levator ani**, on each side, is covered on both pelvic and perineal surfaces with fascia, called superior and inferior fasciæ of pelvic diaphragm. **Coccygeus** is covered with fascia on its pelvic surface, and its dorsal surface is fused with and supported by lig. sacro-spinosum.

The floor is supplemented anteriorly, and on an inferior plane, by the sphincter urethræ and deep transverse perineal muscles, enclosed between superior and inferior fasciæ of urogenital diaphragm (deep and superficial layers of triangular ligament), the relations of which are given on p. 247.

Between the anterior borders of the levatores ani there is a triangular interval, the base of which is formed by symphysis pubis and adjoining pelvic surfaces of pubic bones. Posteriorly, there is an interval between coccygeus and piriformis, which extends laterally, between piriformis and lower margin of greater sciatic notch.

Structures piercing the Floor.—**Rectum**, as it becomes anal canal, pierces the floor in median plane, where floor is formed by levatores.

Fifth sacral and the **coccygeal nerve** descend from hiatus sacralis and pass into pelvis by piercing sacro-tuberos and sacro-spinous ligaments (great and small sacro-sciatic) and the coccygeus, above and below transverse process of 1st piece of coccyx, respectively. They communicate with each other on pelvic surface of coccygeus, and are joined by a branch from 4th sacral, to form coccygeal plexus, from which branches pass dorsally, through coccygeus and the ligaments, to supply skin over coccyx and between coccyx and anus.

Perineal branch of 4th sacral nerve pierces coccygeus and,

either piercing sacro-spinous and sacro-tuberous ligaments or threading its way downwards between them and coccygeus, supplying them, enters posterior angle of ischio-rectal fossa at the side of coccyx, and runs upon perineal surface of levator ani to the external sphincter.

Perforating cutaneous branch of 2nd and 3rd sacral nerves either pierces coccygeus or passes out between it and levator ani, and, turning dorsally, it perforates sacro-tuberous lig. and lower border of gluteus maximus, and supplies skin of lower part of buttock.

Structures related to Pelvic Surface of Floor.—The viscera in relation are imbedded in fascia and fat, which separate them from the muscles; and vessels and nerves traverse the fascia to reach the viscera.

Rectum is related to a great part of pelvic surfaces of coccygei and levatores, before piercing the floor. A portion of infero-lateral surface of **bladder**, on each side, and upper part of **prostate** are related to anterior part of levator. Lateral aspect of **seminal vesicle** is related to posterior part of levator, its upper end lying at the side of rectum, opposite ischial spine. **Ureter** runs downwards, ventrally and medially, in relation to posterior part of levator, from the level of ischial spine towards postero-lateral angle of bladder. **Ductus deferens** is separated by ureter from posterior part of levator, near ischial spine, where ductus turns sharply medially.

Middle hæmorrhoidal and inferior vesical vessels run medially towards rectum and bladder, upon levator, on a deeper plane than the ureter.

(Obturator vessels and nerve and obliterated umbilical artery and its superior vesical branches are above the level of origin of levator ani, *i.e.* nearer the superior aperture of pelvis.)

In the female the relations of **rectum** and **bladder** to pelvic floor are as in the male. Uterus, uterine tubes and ovaries are above the level of the levatores. **Broad ligament**, on each side, is attached to levator, lateral to vagina. **Ureter** runs downwards, ventrally and medially upon levator, beneath broad ligament. **Uterine artery** runs medially upon levator, between the layers of broad ligament, at their attachment to pelvic floor, and crosses above ureter. **Vaginal artery** takes the place of inferior vesical, and lies on levator, below plane of ureter. **Middle hæmorrhoidal artery** is as in male.

Structures leaving Pelvis through Interval posterior to Floor

Sciatic nerve (great sciatic) leaves pelvis between piriformis and lower margin of greater sciatic notch; **inferior gluteal nerve** and **posterior cutaneous nerve of thigh** (small sciatic) leave the pelvis, posterior to sciatic nerve; and **nerve to quadratus femoris** passes out anterior to sciatic nerve.

Nerve to obturator internus passes out between piriformis and base of ischial spine, medial to sciatic nerve, lateral to internal pudendal vessels. It crosses base of ischial spine in buttock, gives

a branch to superior gemellus, and passes through lesser sciatic foramen to enter perineal surface of obturator internus. **Pudendal nerve** (internal pudic) passes out between piriformis and coxeygeus.

Internal pudendal vessels leave the pelvis between piriformis and tip of ischial spine, on medial side of nerve to obturator internus, lateral to pudendal nerve. In the buttock the vessels cross the tip of ischial spine, the pudendal nerve crosses sacro-spinous lig. (small sacro-sciatic), and all pass through lesser sciatic foramen to enter Alcock's canal, on lateral wall of ischio-rectal fossa. **Inferior gluteal vessels** (sciatic) pass out between piriformis and lower margin of greater sciatic notch, on the medial side of sciatic nerve.

Spinal nerves lie external to fascia in the pelvis, and their branches to viscera (from 2nd, 3rd, 4th sacral) pierce the fascia to reach them. Vessels lie in the fascia or between peritoneum and fascia, and those which pass out of the pelvis pierce the fascia before doing so.

Structures occupying Interval between Anterior Borders of Levatores Ani

Prostate occupies greater part of the interval, the borders of the levatores embracing it. A condensation of fascia, called **pubo-prostatic** or **pubo-vesical ligaments**, lies above the anterior part of the interval, stretching from pelvic surfaces of pubic bones to base of prostate and neck of bladder. Within the prostate is the **urethra**; and the prostate is surrounded by a fascial sheath in which there is the **pudendal (prostatic) plexus of veins**. The fascia is merely part of general fascial investment of viscera, and is continuous with pubo-prostatic lig. above and anteriorly, with fascia on levator ani on each side, with fascia of rectum posteriorly, and below with superior fascia of urogenital diaphragm (deep layer of triangular lig.), upon which the apex of prostate rests. **Deep dorsal vein of penis** passes through the interval which separates fasciæ of urogenital diaphragm from arcuate (sub-pubic) lig., and it enters anterior part of pudendal (prostatic) plexus.

Between superior fascia of urogenital diaphragm and the plane of the levatores there is a small interval occupied by loose fascia, veins, lower part of prostate, and "recto-urethral" muscle (p. 460).

In the female, the **vagina** occupies the great part of interval between anterior borders of levatores. These borders clasp the vagina, forming a second sphincter for it, as it passes downwards between them to pierce both fasciæ of the urogenital diaphragm. Fascia containing veins surrounds the vagina. *Pubo-vesical ligaments* extend from pubic bones to neck of bladder, above anterior part of the interval between levatores. **Urethra** passes out of pelvis imbedded in anterior wall of vagina. **Dorsal vein of clitoris** passes through space between urogenital diaphragm and arcuate (sub-pubic) ligament, and ascends to end in vesical plexus of veins.

BLOOD VASCULAR SYSTEM

Heart, the propulsive organ ; **arteries**, the tubes or vessels through which blood is sent from heart ; **veins**, the vessels through which blood returns to heart ; **capillaries**, the microscopic vessels in which arteries end and veins begin.

COR (THE HEART)

The **heart** is a hollow muscular organ, completely subdivided by 2 *septa* into right and left halves. Each half consists of (1) **atrium** (O.T. auricle), which receives blood from veins ; and (2) **ventricle**, which propels blood into arteries. **Sulcus coronarius**, a shallow groove encircling heart at right angles to its long axis, indicates, on surface, the subdivision into atria and ventricles. Separation of atrial part into halves is indicated on surface, only at base of heart, by indistinct sulcus. Separation of ventricular part is indicated on surface by definite **anterior** and **inferior longitudinal sulci**.

Ear-shaped ventral prolongations of atria are called **right** and **left auricles** (O.T. auricular appendices).

Right atrium receives impure blood from almost every part of body, by two large veins—**venæ cavæ**, **superior** et **inferior**, and from substance of heart by **sinus coronarius** and some small veins. Contraction of atrium sends blood into right ventricle through a large aperture, guarded by a valve to prevent return of blood into atrium.

Right ventricle, by contracting, propels impure blood, received from atrium, into a large artery called the **pulmonary artery**, which divides into right and left branches, called *right* and *left pulmonary arteries*. These convey blood to lungs to be oxygenated. **Right** and **left pulmonary veins**,

two from each lung, carry oxygenated blood to **left atrium**, which propels it into left ventricle through a large opening, guarded by a valve.

Left ventricle contracts to drive oxygenated blood into a large artery called **aorta**, by whose branches blood is distributed to all parts of body.

Atria contract simultaneously, and ventricles contract simultaneously, immediately after the atria.

Substance of heart is mainly muscular—**myocardium**—covered with serous membrane called **epicardium**; while interior of chambers of heart is lined with smooth adherent membrane called **endocardium**. Heart, together with proximal parts of great vessels, is enclosed in fibro-serous sac called **pericardium**, situated in middle mediastinum of thorax, about two-thirds lying to left of median plane and one-third to the right. Long axis of heart runs from behind forwards, to the left and downwards. **Size and capacity**: 5 inches long; $3\frac{1}{2}$ inches broad; greatest thickness $2\frac{1}{2}$ inches. Each ventricle holds about 4 oz.; atria, a little less. Size increases rapidly up to age of 20, thereafter gradually up to age of 50. **Weight** in adult male 11 oz., female 9 oz.

Shape. — Irregular and flattened cone, possessing base, apex and two surfaces. **Basis cordis**, formed by atria—almost entirely by left atrium—looks dorsally, upwards and to the right; lies opposite 5th, 6th, 7th, 8th thoracic vertebræ, and is separated by pericardium from œsophagus and descending aorta. Base is irregularly quadrilateral. At upper and lower angles, on right side, are the openings of superior and inferior venæ cavæ. To the left of these, and on a plane between them, are the openings of two right pulmonary veins; and immediately to the right of these is an indistinct groove, between right and left atria, descending to the left of opening of inferior cava. Near left border of base are the openings of two left pulmonary veins. Vena obliqua atrii sinistri (Marshall) lies below the lower of these. Base is limited below by coronary sulcus, containing coronary sinus. Upper border is in relation to bifurcation of pulmonary artery, and to its right branch, *i.e.* the right pulmonary artery.

Apex cordis, formed by left ventricle, lies $3\frac{1}{2}$ inches from median plane, opposite 5th left intercostal space, from which it is separated by pleura and lung.

Diaphragmatic surface (inferior), formed by ventricles, chiefly by left ventricle, rests on diaphragm, which separates

it from liver and stomach. **Inferior longitudinal sulcus** traverses it, from base to right side of apex.

Sterno-costal surface (antero-superior), formed by both atria and their auricles, and both ventricles : overlapped by pleuræ and lungs ; lies behind body of sternum and 3rd, 4th, 5th, 6th costal cartilages of both sides, but more on left side than right. *Atrial part*, with its *auricles*, is concave or crescentic, embracing roots of ascending aorta and pulmonary art. *Ventricular part*, formed chiefly by right ventricle, is convex and is traversed by **anterior longitudinal sulcus** ; at the upper part are the orifices of aorta and pulmonary art., the latter being anterior, above and to the left.

Right margin, formed by right atrium, slightly convex, lies posterior to 3rd, 4th, 5th, 6th cartilages, $\frac{1}{2}$ inch from sternum. **Lower margin**, formed almost entirely by right ventricle, extends from 6th right cartilage to apex of heart, which is formed by left ventricle. **Left margin**, convex, formed by left ventricle and atrium, extends from above 3rd cartilage, 1 inch from sternum, to the apex, obliquely, with a convexity to the left. **Upper margin**, formed by atria and auricles, extends from below 2nd left cartilage, 1 inch from sternum, to upper border of 3rd right cartilage, $\frac{1}{2}$ inch from sternum.

Atrial part of heart is cuboidal in form, but is elongated transversely. Upper part is crescentic, with concavity directed forwards, chiefly owing to forward projection of *auricles*.

Right atrium, with its *auricle*, encloses one cavity, cuboidal in shape, situated at right border and base of heart, posterior to and above ventricle. Septum atriorum is oblique, so that right atrium is to right of and anterior to left. Superior vena cava enters atrium above and posteriorly ; inferior cava enters below and posteriorly. Between these, the lower right pulmonary vein lies posterior to atrium. Root of aorta is above and anterior, and auricle is prolonged anteriorly along its right side, as far as root of pulmonary artery. Shallow **sulcus terminalis**, extending from ant. aspect of sup. cava to that of inf. cava, indicates on surface the division of chamber into sinus venosus and atrium proper. *Sinus venosus* is the part of atrium behind sulcus terminalis, and the veins open into it. There are no *musculi pectinati* on its internal surface. Pericardium separates atrium proper from pleura and lung, and separates sinus venosus from phrenic nerve and accompanying vessels as well.

In the *interior* the following are to be noted: **Atrio-ventricular (tricuspid) orifice**, at lower and anterior part, leading into ventricle. **Opening of inf. vena cava**, at lower and posterior part. **Valve of inf. vena cava (Eustachian)**, a thin and sometimes fenestrated fold, at anterior and lower part of caval opening. **Opening of coronary sinus**, close to septum, between valve of inf. vena cava and atrio-ventricular orifice, and guarded by incompetent uni-cuspid **valve of coronary sinus (Thebesian)**. **Fossa ovalis**, a depression on septum above opening of inferior cava. **Limbus fossæ ovalis (annulus ovalis)**, a curved ridge above and anterior to f. ovalis, and continuous below with valve of inf. vena cava. Fossa ovalis represents *foramen ovale*, by which atria communicated before birth. Foramen may persist as small aperture under cover of upper part of limbus. **Opening of vena cava sup.**, at upper and back part of atrium. **Tuberculum intervenosum (of Lower)**, between openings of venæ cavæ, posterior to upper part of f. ovalis (cannot be seen in flaccid specimens). **Crista terminalis**, a strong muscular ridge, between caval openings, corresponding in position to sulcus terminalis on surface. **Musculi pectinati**, numerous parallel muscular ridges extending from crista over wall of atrium and auricle. Crista term. and valves of v. cava inf. and coron. sinus indicate junction of atrium proper and sinus venosus. **Foramina venarum minimarum** are small fossæ scattered over walls of atrium; venæ minimæ from substance of heart open into some of them.

Left atrium, with its **auricle**, also encloses one cavity, cuboidal in shape. **Auricle**, much smaller than on right side, is an elongated prolongation from anterior and upper part of atrium, and lies at left side of aorta and pulmonary artery, behind upper part of 3rd left cartilage and lower part of 2nd space. *Musculi pectinati* are found in its interior. **Atrium** lies posterior to and above left ventricle, to the left of and posterior to right atrium. Its posterior surface forms greater part of base of heart, and the anterior wall of oblique sinus of pericardium. It is separated from œsophagus and descending aorta by pericardium. Anterior surface is hidden by ascending aorta and pulmonary artery. Bifurcation of pulmonary artery is at its upper border. In its interior are (a) *openings of four pulmonary veins* at upper part of posterior surface, two on right side, two on left; (b) several scattered *foramina venarum minimarum*;

(c) *large atrio-ventricular opening* (bicuspid or mitral orifice) at lower and anterior part, leading into left ventricle.

Ventricular part of heart forms larger and lower part, and is conical and somewhat flattened. *Base*, directed dorsally and upwards, is partly free, partly connected with walls of atria and the two great arteries, but is chiefly occupied by apertures; *atrio-ventricular*, one on each side, behind and below; *aortic*, anterior to these two and between them; *pulmonary*, anterior and to the left of aortic. In interval between aortic and atrio-ventricular orifices a *fibro-cartilaginous body* is imbedded. It represents os cordis of ox, and is continuous with septum ventriculorum below, and with fibrous rings surrounding apertures. These orifices lie behind a broad line drawn from 3rd left chondro-sternal junction *towards* 6th right, but stopping opposite 5th right.

Septum ventriculorum extends from ventricular base to right side of apex. Obliquely placed, so that right ventricle is anterior to, as well as on right side of, left ventricle; position is indicated on surface of heart by anterior and inferior longitudinal (inter-ventricular) furrows. Lower part, developed from ventricular part of heart, is muscular; upper smaller part, developed from septum of bulbus cordis, is membranous (*pars membranacea*), and separates upper part of left ventricle not only from upper part of right ventricle, but also from lower part of right atrium.

Right ventricle is below and anterior to right atrium, to the right of and anterior to left ventricle. Forms greater part of sterno-costal surface of heart. Triangular in shape. *Base*, directed dorsally and upwards, is continuous with atrium below and posteriorly, gives origin to pulmonary artery anteriorly, superiorly, and to the left. *Inferior surface* is in relation to diaphragm. *Sterno-costal surface*, in relation to sternum and 3rd, 4th, 5th, 6th *left* costal cartilages, is roughly within limits of triangle bounded by lines: (1) from upper border of 3rd left cartilage, near sternum, to 6th right costal cartilage; (2) from there across to 5th left inter-space, 3 inches from mid-sternal line; (3) from there up to 3rd cartilage.

Area of Absolute Cardiac Dulness.—Pleurae and lungs overlap and cover pericardium and heart, except over lower part of right ventricle, which gives completely dull note on percussion. Area can be mapped out with sufficient accuracy by three lines: (1) vertical line a little to left of mid-sternal line, from level of 4th cartilage

(point A) to level of 6th cartilage (point B); (2) horizontal line drawn to the left from point B for $2\frac{1}{2}$ inches (point C); (3) curved line, slightly convex upwards and to the left, uniting points C and A. Pericardium in the part of this area posterior to sternum is uncovered by pleura; in the part lateral to sternum it is covered by pleura, but not by lung.

Cavity of right ventricle is semilunar on section, as septum bulges into it, and is a tube bent on itself to form a lower part—**body**—into which atrium opens, and antero-superior part—**conus arteriosus**—from which pulmonary artery springs. Angle between two parts is formed by thick ledge of muscle.

Right atrio-ventricular orifice can admit three fingers. Situated posterior to right half of sternum, opposite fourth intercostal space. It is guarded by **tricuspid valve**, consisting of three large cusps or flaps—*cusps anterior*, (infundibular), *c. inferior* (marginal), *c. medialis* (septal), each triangular in shape, and attached by *base* to fibrous ring surrounding orifice. Their basal angles may meet or may be separated by small intermediate cusps. Each consists of a fold of endocardium enclosing a little fibrous tissue. They project into cavity of ventricle, anterior cusp between orifice and conus arteriosus, inferior in relation to lower surface, medial in relation to the septum. Their *atrial surfaces*, over which blood passes, are smooth; *ventricular surfaces* are roughened by chordæ tendineæ, which are inserted into ventricular surfaces, apices and margins of cusps.

Pulmonary orifice is situated posterior to margin of sternum and the end of 3rd left costal cartilage, at level of its upper border. Guarded by **valve** of three semilunar segments—*posterior*, *right* and *left*—attached by convex borders to root of pulmonary artery. Concave border of each is free, and presents a small *nodule* at its middle, and, on each side of nodule, a small *lunule*, thinner than rest of flap. When valve is open, segments are projected into artery by blood-stream; when it is closed, the nodules and lunules are pressed together, and their edges project upwards into artery.

Cavity of conus arteriosus is smooth. Cavity of body is rugose and spongy, owing to large number of muscular projections called **trabeculæ carneæ**. These are of two kinds: (1) mere *ridges*; (2) *bridges*, attached at both ends, free in middle. Most important of these is the **moderator band**, stretching across cavity, from base of anterior papillary

muscle to septum. **Musculi papillares**, conical bundles continuous by their bases with wall of ventricle, give rise by apices to fine tendons called **chordæ tendineæ**, which are inserted into cusps of tricuspid valve. Three sets of chordæ tendineæ : (1) from large anterior papillary muscle to anterior and inferior cusps ; (2) from small and irregular inferior muscle to inferior and medial cusps ; (3) from small papillary projections on septum to medial and anterior cusps.

Left ventricle—below and anterior to left atrium, to the left of and posterior to right ventricle—forms small part of sterno-costal surface, greater part of left border and diaphragmatic surface, and whole apex. Conical in shape. *Base*, directed dorsally and upwards, is continuous, by its lower and posterior part, with left atrium ; and gives origin to aorta above, anteriorly and to the right.

Cavity is oval on section, and is divided into large **body**, into which atrium opens, and small **aortic vestibule**, situated above and anteriorly, below aortic orifice, and bounded by membranous part of septum and anterior cusp of mitral valve.

Left atrio-ventricular orifice can admit two fingers, Situated posterior to left half of sternum, opposite 4th costal cartilage. Guarded by **bicuspid valve (mitral)**, consisting of two large cusps—*anterior* and *posterior*—resembling those of right side. The anterior, situated between atrio-ventricular and aortic orifices, is larger than the posterior, and is smooth on both surfaces, as blood passes into ventricle over one surface, and out of it over the other surface. Small intermediate cusps are usually placed between them at bases.

Aortic orifice is situated posterior to left half of sternum, close to margin, opposite lower border of 3rd cartilage. Guarded by **valve** of 3 segments, *anterior*, *right*, and *left*, resembling those of pulmonary valve.

Cavity is smooth walled in aortic vestibule and over septum, rough and sponge-like elsewhere, owing to **trabeculæ carneæ**. **Papillary muscles**—anterior and posterior—are large, and chordæ tendineæ go from each to both cusps of mitral valve. Muscular wall of cavity (including septum) is three times as thick as that of right ventricle.

Blood supply of substance of heart : coronary branches of aorta. **Lymphatics** end in mediastinal and tracheal glands. **Nerves**, through cardiac plexuses, from cervical sympathetic, vagus, and accessory through vagus.

PERICARDIUM

A fibro-serous sac enveloping heart and roots of great vessels. Situated in middle mediastinum. Conical in shape, base below, blunted apex above. **Relations.**—**Anterior**: lower end of thymus; lungs and pleuræ; body of sternum, 2nd to 6th costal cartilages of both sides. It is in direct contact with lower left half of sternum. (See area of absolute dulness, p. 257.) *Sup. and inf. sterno-pericardial lig.*s. connect it to manubrium and to xiphoid process. **Lateral**: lungs and mediastinal pleura, lig. pulmonale, phrenic nerve and accompanying pericardiaco-phrenic vessels. **Posterior**: descending thoracic aorta, œsophagus and vagi, upper ends of bronchi. **Inferior**: diaphragm separates it from liver and stomach. **Superior**: aortic arch, vena cava superior; pretracheal fascia, which fuses with it.

Fibrous pericardium is the outer layer. Below, it is attached to diaphragm and is pierced by inferior v. cava. Above and posteriorly, it fuses with sheaths of aorta, right and left pulmonary arteries, vena cava superior, four pulmonary veins, as these various vessels pierce it.

Serous pericardium consists of **parietal** layer lining fibrous pericardium, and **visceral layer** reflected over great vessels on to heart, where it forms **epicardium**. As serous layer passes from fibrous layer to heart it completely envelops aorta and pulmonary artery in a single sheath, while veins receive each a partial covering, a portion of one surface lying in contact with fibrous pericardium.

Sinus pericardii transversus is a space behind aorta and pulmonary art., through which the finger can be passed from side to side when pericardium is opened. It is bounded *anteriorly* by aorta and pulmonary art.; *posteriorly* by atria; *superiorly* by right pulm. art., and reflection of serous pericardium from atria on to arteries. **Sinus pericardii obliquus** is a space dorsal to left atrium, between the right and left pulmonary veins, limited above by reflection of serous pericardium from fibrous pericardium on to upper part of atria. **Ligamentum v. cavæ sinistrae** (vestigial fold of Marshall) is a small fold of serous pericardium stretching between left pulmonary art. and upper left pulmonary vein. It contains fibrous remnant of foetal left superior vena cava.

Arteries of pericardium, from pericardiaco-phrenic, internal

mammary, musculo-phrenic, aorta. **Nerves**, from phrenic, vagus, sympathetic. **Lymphatics** end in anterior and posterior mediastinal glands.

ARTERIA PULMONALIS

Pulmonary artery springs from conus arteriosus, at base of right ventricle; extends upwards and posteriorly for 2 inches, to end below concavity of aortic arch by dividing into right and left branches. At origin it shows three bulgings—**pulmonary sinuses**—opposite cusps of valve. **Ramus dexter (right pulmonary artery)**.—*Extra-pulmonary part*, longer and larger than left, extends from bifurcation to hilum of right lung; it gives off a branch to accompany eparterial bronchus. *Intra-pulmonary part* descends along postero-lateral aspect of stem bronchus and gives off branches to accompany dorsal, ventral, and accessory branches of bronchus. **Ramus sinister (left pulmonary artery)**.—*Extra-pulmonary part*, extends from bifurcation to hilum of left lung; before entering, it gives branch to upper lobe. *Intra-pulmonary part* as on right side.

Relations—Pulmonary Trunk.—Within fibrous pericardium, enclosed with ascending aorta in tube of serous pericardium. *Anterior*: sternal end of 2nd left intercostal space, left pleura and lung intervening. *Posterior*: ascending aorta and left coronary artery below, left atrium above. *To the right*: right auricle and coronary artery below, ascending aorta above. *To the left*: left auricle and left coronary artery; left pleura and lung. *Above its bifurcation*: superficial cardiac plexus, aortic arch.

Right Branch.—*Anterior*: ascending aorta, upper right pulm. vein, v. cava sup. *Superior*: aortic arch, right bronchus, eparterial bronchus. *Posterior*: cesophagus, hyparterial bronchus. *Inferior*: left atrium, transverse sinus, lower right pulmonary vein.

Left Branch.—*Anterior*: upper left pulm. vein. *Superior*: recurrent nerve, aortic arch, lig. arteriosum. *Posterior*: descending aorta, left bronchus. *Inferior*: lower left pulmonary vein.

Lig. Arteriosum, a fibrous remnant of fetal ductus arteriosus, passes from root of left pulmonary artery to aortic arch, in substance of fibrous pericardium. Recurrent nerve hooks round its left side, at attachment to aorta; superficial cardiac plexus lies to its right side.

SYSTEMIC ARTERIES

Aorta is the main systemic arterial trunk. It springs from left ventricle, and ascends to 2nd right cost. cartilage (ascending aorta). From there it is directed, *posteriorly* and to the left, to lower border of 4th thoracic vertebra (arch of aorta). From there it descends on ventral aspect of vertebral column to end at 4th lumbar vertebra (descending aorta, divided into descending thoracic aorta and abdominal aorta).

Ascending aorta springs from base of left ventricle; extends upwards, anteriorly and to the right, for 2 in., to end behind right margin of sternum, opposite 2nd cartilage, by becoming continuous with aortic arch. At origin it has 3 bulgings, called *aortic sinuses* (Valsalva), opposite cusps of valve.

Branches: right and left coronary arteries.

Relations: within fibrous pericardium, enclosed with pulmonary in tube of serous pericardium. *Anterior*: upper part of conus arteriosus and root of pulm. artery; right lung and pleura; sternum. *Right side*: right auricle, v. cava sup. *Posterior*: right atrium, right pulm. art., right bronchus, and v. cava slightly. *Left side*: left auricle, pulmonary art.; left pleura and lung.

Aortic arch begins, as continuation of asc. aorta, behind right margin of sternum opposite 2nd cartilage, and extends backwards and to the left, across sup. mediastinum, behind lower $\frac{1}{2}$ of manubrium, to end at left side of lower border of 4th TH. vertebra, by becoming continuous with descending aorta. Curved in two planes, one curve concave downwards, the other concave posteriorly and to the right.

Branches.—Innominate, left common carotid, left subclavian.

Relations.—*Anterior and to left*: left phrenic, lower cervical cardiac branch of left vagus, upper cerv. card. br. of left sympathetic, left vagus; left superior intercostal vein; thymus, left pleura and lung; right pleura and lung slightly. *Posterior and to right*: trachea, deep cardiac plexus, left recurrent nerve, œsophagus, thoracic duct. *Superior*: its own branches and left innominate vein. *Inferior*: bifurcation of pulmonary art., root of left lung; superficial cardiac plexus, ligamentum arteriosum, left recurrent nerve.

Descending thoracic aorta begins, as a continuation of arch, at left side of lower border of 4th TH. vertebra: descends

through post. mediastinum, on ventral surface of vertebral column, inclining anteriorly and to the right to gain median plane; ends by passing through hiatus aorticus of diaphragm, opposite fibro-cartilage between 12th thoracic and 1st lumbar vertebræ, and becoming continuous with abdominal aorta.

Branches.—9 pairs of intercostals, 1 pair of subcostals, superior phrenics, the 2 left bronchial, sometimes the right bronchial, 4 or 5 œsophageal, a few pericardial and mediastinal.

Relations.—*Anterior*: root of left lung, pericardium and left atrium, œsophagus, diaphragm. *Left side*: left pleura and lung. *Right side*: thoracic duct, vena azygos; œsophagus above; right lung and pleura below, separated by fatty areolar tissue. *Posterior*: lower 8 thoracic vertebræ, vena hemiazygos and v. hemiazygos accessoria.

Abdominal aorta begins at fibro-cartilage between 12th TH. and 1st L. vertebræ, between crura of diaphragm, as continuation of thoracic aorta; passes downwards and slightly to left, to end on ventral surface of 4th lumbar vertebra, to the left of median plane, $\frac{1}{2}$ inch below and to left of umbilicus, by dividing into right and left common iliac arteries.

Branches.—*Paired visceral*: middle suprarenal, renal, internal spermatic or ovarian. *Unpaired visceral*: celiac, superior and inferior mesenteric. *Paired parietal*: inferior phrenic, 4 lumbar. *Unpaired parietal*: middle sacral.

Relations.—*Anterior*: celiac artery and plexus; pancreas and splenic vein; sup. mesenteric art., left renal vein, 3rd part of duodenum; root of mesentery and sup. mesenteric vessels; aortic plexus, inf. mesent. art.; peritoneum and coils of small intestine. *Right side*: vena cava, below; thoracic duct, vena azygos, right crus of diaphragm, above. *Left side*: left crus, termination of duodenum, peritoneum and coils of intestine; sympathetic trunk and inf. mesenteric vein and ureter, a little distance away. *Posterior*: upper 4 L. vertebræ, ant. longitudinal lig., left lumbar veins. Lumbar and middle sacral arteries spring from dorsal aspect.

BRANCHES OF ASCENDING AORTA

Right coronary artery springs from anterior sinus aortæ (of Valsalva), passes anteriorly, between pulmonary art. and right auricle, to coronary (auriculo-ventricular) groove, in which it runs, accompanied by right coronary vein and plexus of nerves, as far as inferior longi-

tudinal sulcus. Ends there by dividing into large **inferior branch**, which runs forward in inf. long. sulcus to apex, and **circumflex branch**, which runs transversely across to anastomose with corresponding left artery. Other branches are given to pulm. art., aorta, atrium and auricle, and ventricle, largest being *marginal*, which runs along lower margin of right ventricle.

Left coronary artery springs from left sinus aortae, passes anteriorly, between pulm. art. and left auricle, to upper end of sulcus longitud. ant.; there it divides into two :—(1) **anterior descending branch** descends in that sulcus to apex to anastomose with inferior branch of right coronary; (2) **circumflex branch** runs in coronary sulcus, accompanied by vein and nerves, to anastomose with circumflex branch of right coronary. Gives branches, like the right, to great arteries, atrium, auricle and ventricle. Circumflex branch lies below coronary sinus at base of heart.

BRANCHES OF AORTIC ARCH

Arteria anonyma (Innominate) springs from convexity of aortic arch, opposite centre of manubrium; runs upwards, to the right and posteriorly, for $1\frac{1}{2}$ or 2 inches, to end behind upper part of sterno-clavicular joint, by dividing into right common carotid and right subclavian. See also pp. 211, 428.

Branches: these two and occasional thyreoidea ima.

Relations.—*Anterior:* left innominate vein, thymus; sterno-thyroid, sterno-hyoid, manubrium and sterno-clavicular joint. *Right side:* right innominate vein and sup. v. cava; phrenic nerve, pleura and lung. *Left side:* left common carotid below, trachea above. *Posterior:* trachea below; above, it is separated from longus colli, and sometimes from pleura and lung, by fat and areolar tissue.

A. thyreoidea ima, rarely present. Springs from innominate or aortic arch. Ascends on anterior surface of trachea to end in thyroid gland.

Left common carotid artery springs from convexity of aortic arch, behind and to left of innominate, and close to it. Runs upwards and slightly to the left for 1 or $1\frac{1}{2}$ inches, to enter neck behind lower part of sterno-clav. joint. Thence upwards and slightly laterally for $3\frac{1}{2}$ inches, along lower part of line leading from sterno-clav. joint to mid-point between angle of mandible and mastoid process. Ends by dividing into ext. and int. carotids opposite upper border of thyroid cartilage and lower border of 3rd cervical vertebra.

Branches: only the terminals.

Relations.—**In thorax:** *Anterior:* root of innominate art., left innominate vein; remains of thymus, overlapping left pleura and lung; sterno-thyreoid and sterno-hyoid; manubrium. *Right side:* innominate art. below, trachea above. *Left side:* vagus, phrenic; cervical cardiac branches of left vagus and sympathetic; subclavian artery on a posterior plane; pleura and lung. *Posterior:* subclavian artery, and successively from below upwards, trachea, recurrent nerve, œsophagus. See also p. 428.

In neck, enclosed with int. jugular vein and vagus in carotid sheath. *Superficial, in lower part of the neck:* sterno-clavicular joint, sterno-mastoid; anterior jugular vein; infra-hyoid muscles; ansa hypoglossi, middle thyreoid vein, and overlapping lateral lobe of thyreoid gland. *Superficial, in carotid triangle:* sterno-mastoid overlapping; sterno-mastoid artery, superior thyreoid vein; descendens hypoglossi. *Laterally:* int. jugular vein; vagus on post. plane. *Medially:* trachea, recurrent nerve and œsophagus, below; larynx and pharynx, above. Thyreoid gland is medial and overlaps it. *Posterior:* longus colli and longus capitis (rect. cap. ant. major); sympathetic trunk; inferior thyreoid artery, thoracic duct, vertebral artery. See also pp. 211, 216.

Right common carotid artery arises, as a branch of bifurcation of innominate, behind upper part of sterno-clavicular joint. Course, termination, and relations resemble those of left artery in its course above sterno-clavicular joint, *with these differences:* left internal jugular vein overlaps lower part of left artery, but right vein is separated from lower part of right artery by interval in which vagus descends. Right lymphatic duct takes the place of thoracic duct. (Esophagus is in less intimate relation on right side. Recurrent nerve is behind the artery, before it is medial.

External carotid artery begins, as branch of bifurcation of common carotid, opposite upper border of thyreoid cartilage and lower border of 3rd vertebra. Extends upwards and laterally for $2\frac{1}{2}$ inches to end behind neck of mandible, between it and parotid gland, by dividing into superficial temporal and internal maxillary. Position indicated by a line drawn from a point just below tip of greater horn of hyoid bone to lobule of ear. See also pp. 219, 445.

Branches: sup. thyreoid, ascending pharyngeal, lingual, ext. maxillary (facial), occipital, post. auricular, and terminals.

Relations.—**Superficial:** *Incarotid triangle*: sterno-mastoid overlapping; lingual vein, common facial vein: hypoglossal nerve. *Above carotid triangle*: posterior belly of digastric, stylo-hyoid; facial nerve and posterior facial vein in substance of parotid gland, which first overlaps and then envelops artery. **Deep**: inferior constrictor below and int. carotid above, but separated from int. carotid and pharynx above by parotid gland, styloid process, stylo-pharyngeus muscle, glosso-pharyngeal n., pharyngeal branches of vagus and sympathetic. Superior laryngeal nerve and its branches are deep to both ext. and int. carotid arteries.

Superior thyreoid artery arises from external carotid near its origin, anteriorly; runs downwards, forwards, and medially to end in thyreoid gland. **Relations:** *Superficial*: sterno-mastoid overlapping origin; omo-hyoid, sterno-hyoid, sterno-thyreoid; superior thyreoid vein. *Deep*: inferior constrictor, external laryngeal nerve. See also pp. 210, 219.

Branches.—Hyoid, superior laryngeal, sterno-mastoid, crico-thyreoid, glandular, muscular.

Hyoid branch runs along lower border of hyoid bone, under cover of thyreo-hyoid muscle. **Superior laryngeal** runs forwards beneath thyreo-hyoid, pierces thyreo-hyoid membrane, together with int. laryngeal n., and supplies mucous membrane, muscles, and ligaments of larynx. **Sterno-mastoid branch** crosses common carotid to enter sterno-mastoid. **Crico-thyreoid** runs anteriorly, over or under sterno-thyreoid, over crico-thyreoid, to anterior surface of crico-thyreoid ligament, and anastomoses with its fellow. **Terminal branches**, *anterior* and *posterior*, supply thyreoid gland and adjacent muscles.

Ascending pharyngeal artery arises from ext. carotid near origin, medially; runs upwards to base of skull, giving branches to pharynx and prevertebral muscles, and ends in meningeal branches. **Relations:** *Medial*: constrictors of pharynx. *Posterior*: longus capitis (rect. cap. ant. major). *Lateral*: int. carotid. *Crossed anteriorly* by stylo-pharyngeus, glosso-pharyngeal nerve, pharyngeal branch of vagus.

Branches.—(1) **Pharyngeal**, to pharynx, palatine tonsil, auditory tube; (2) **prevertebral**, to prevertebral muscles and lymph glands; (3) **posterior meningeal**, one or more, pass through canalis hypoglossi (ant. condyloid foramen), for. jugulare or f. lacerum to meninges; (4) **inferior tympanic** accompanies tympanic nerve to tympanum; (5) **palatine**, when present, pierces pharyngeal aponeurosis and accompanies levator veli palatini to soft palate.

Lingual artery springs from ext. carotid, opposite tip of greater horn of hyoid ; **1st part** forms loop, convex upwards, which lies upon middle constrictor, above tip of greater horn, and is crossed by hypoglossal nerve ; **2nd part** runs forwards along upper border of hyoid, upon middle constrictor and genio-glossus, covered by hyoglossus ; and ends as **profunda linguæ** (ranine), which runs upwards under ant. border of hyoglossus, and then forwards on inferior surface of tongue to its tip. See also p. 225.

Branches.—(1) **Hyoid branch**, from 1st part, runs along upper border of hyoid bone. (2) **Dorsales linguæ**, from 2nd part, ascend between hyoglossus and genio-glossus and supply dorsum of tongue and palatine tonsil. (3) **A. sublingualis** springs from commencement of profunda ; runs upwards and forwards, between mylo-hyoid and genio-glossus, to sublingual gland.

External maxillary artery (facial) arises immediately above lingual. Ascends medial to post. belly of digastric and stylo-hyoid and deep surface of angle of mandible, and in a groove in post. end of submaxillary gland ; then forwards and downwards, between submaxillary gland and pterygoideus internus, to lower border of mandible. Pierces deep fascia and crosses mandible at ant. border of masseter and runs a tortuous course, upwards and medially, $\frac{1}{2}$ in. from angle of mouth, to end, near medial angle of eye, as angular artery.

Relations in Neck.—**Superficial** : digastric and stylo-hyoid ; angle of mandible and pterygoideus internus ; submaxillary gland. **Deep** : middle and superior constrictors, the latter separating it from palatine tonsil ; submaxillary gland envelops it.

Branches in Neck.—Asc. palatine, tonsillar, submaxillary, submental.

(1) **Ascending palatine** runs up, between pterygoideus int. and sup. constrictor, and between stylo-glossus and -pharyngeus, to apex of petrous temporal ; turns down with lev. veli palatini, pierces pharyng. aponeurosis, to end in soft palate. *Supplies* pharynx, palate, palatine tonsil, auditory tube. (2) **Tonsillar branch** runs up between pterygoideus int. and stylo-glossus, pierces sup. constrictor, ends in palatine tonsil. (3) **Glandular branches** supply submaxillary gland. (4) **Submental art.** arises where facial turns up on jaw ; runs forwards, under cover of mandible, to symphysis and turns up on to chin.

Relations in Face.—*Lies upon* mandible, buccinator, caninus (levator anguli oris), and in substance of caput angulare (lev. labii sup. alicque nasi) of quadratus labii superioris. *Covered by*

platysma, risorius, zygomaticus (major), caput infra-orbitale (lev. labii sup.). Vein is behind and at some distance from it, except on mandible at anterior border of masseter, where it is in contact.

Branches in face: inferior and superior labial, lateral nasal, angular, unnamed muscular. (1) **Inferior labial** (inf. coronary) runs forwards, under cover of triangularis (depressor anguli oris) and between mucous membrane of lower lip and orbicularis. Another branch, formerly called inf. labial, arises above lower border of mandible, runs forwards beneath triangularis and quadratus labii inferioris (depressor lab. inf.). (2) **Superior labial** (superior coronary) runs forwards between orbicularis and mucous membrane of upper lip, and sends **septal** branch to septum of nose. (3) **Lateral nasal**, one or more, ramify on side of nose. (4) **Angular art.** is the terminal branch at upper part of side of nose. (5) **Irregular muscular branches** from posterior aspect of artery.

Occipital artery arises just below posterior belly of digastric. Runs upwards and posteriorly, *under cover of* digastric, mastoid process and muscles attached to it, and trapezius, which it pierces, 1 inch or less from ext. occip. protuberance, to ramify over posterior part of scalp. It *lies on* carotid sheath, hypoglossal n. (which hooks round it), accessory n., rectus lateralis, obliquus superior and semispinalis capitis (complexus). See also pp. 220 and 230.

Branches. — (1) **Muscular**, including two **sterno-mastoid branches**, one below accessory nerve and one accompanying it. (2) **Meningeal branches** enter skull through jugular foramen and mastoid foramen. (3) **Ramus descendens** (A. princeps cervicis) arises as occipital lies on obliquus sup., runs medially to lateral border of semispinalis capitis (complexus) and divides into superficial and deep branches, which ramify on corresponding surfaces of semispinalis. (4) **Auricular branch**, when present, supplies skin, etc. over mastoid and cranial surface of auricle. (5) Terminal **rami occipitales**, *medial* and *lateral*, supply post. part of scalp.

Posterior auricular artery arises just above post. belly of digastric, runs upwards and backwards, at first deeply, between parotid and digastric, upon styloid process; then more superficially, between mastoid process and acoustic meatus; and ends in occipital and auricular branches.

Branches. — (1) To parotid and adjacent muscles. (2) **A. stylo-mastoidea** enters stylo-mastoid foramen to ascend, through canalis facialis, to medial wall of tympanum. (3) **R. auricularis** supplies both surfaces of auricle and adjacent scalp. (4) **R. occipitalis** supplies scalp near auricle.

Superficial temporal artery begins behind neck of mandible, as branch of bifurcation of ext. carotid. Ascends over posterior root of zygoma, in front of auricle, accompanied by vein and auriculo-temporal nerve. Ends $1\frac{1}{2}$ or 2 inches above zygomatic arch by dividing into frontal and parietal branches.

Branches.—(1) To upper part of parotid. (2) **Anterior auricular**, to auricle and acoustic meatus. (3) **Transverse facial** runs to the cheek across masseter, between zygomatic arch and parotid duct. (4) **Middle temporal** arises below the zygoma, crosses it, pierces temporal fascia and sinks into temporal muscle. (5) **Zygomatico-orbital** (may arise from middle temporal) lies between two layers of temporal fascia. (6) **Ramus frontalis** runs upwards and anteriorly, tortuously, towards frontal tuberosity (eminence). (7) **R. parietalis** runs upwards and posteriorly towards parietal tuberosity (eminence).

Internal maxillary artery arises, between parotid and back of neck of mandible, as branch of bifurcation of ext. carotid. Extends (1) anteriorly to lower border of pterygoideus externus, between mandible and speno-mandibular ligament, accompanied by vein and auriculo-temporal n. (2) Upwards and anteriorly, superficial to pterygoideus externus, between it and temporal muscle; or deep to pterygoideus ext., between it and branches of mandibular division of trigeminal n. (3) Medially, between two heads of pterygoideus ext., and through pterygo-maxillary fissure into pterygo-palatine fossa, to end in numerous branches.

Branches of (1): deep auricular, anterior tympanic, middle and accessory meningeal, inferior alveolar (dental). **Of (2):** masseteric, deep temporal, pterygoid, buccinator. **Of (3):** posterior superior alveolar (dental), infra-orbital, palatine, artery of pterygoid canal (Vidian), speno-palatine, pharyngeal (pterygo-palatine).

(1.) Branches of First Part.—(a) **Deep auricular** to ext. acoustic meatus. (b) **Anterior tympanic** traverses petro-tympanic fissure, enters tympanic cavity through lateral wall. (c) **Accessory (small) meningeal** runs up, deep to pterygoideus externus; enters middle cranial fossa through for. ovale, and supplies dura mater and semilunar ganglion. (d) **Middle meningeal**. (e) **Inferior alveolar**.

Middle meningeal artery arises at lower border of pterygoideus ext. Runs up between it and speno-mandibular ligament, lateral to tensor tympani, between

roots of auriculo-temporal n., behind mandibular n. Enters middle cranial fossa through for. spinosum, accompanied by a vein. Runs anteriorly and upwards between bone and dura, over squamous temporal and great wing of sphenoid, to end on latter by dividing into ant. and post. branches.

Anterior terminal branch runs upwards and anteriorly, over great wing, to sphenoidal angle of parietal bone, which it deeply grooves or tunnels, and from there upwards and posteriorly, a little behind ant. border of parietal, opposite motor area of brain, to vertex, giving branches backwards and forwards. Position may be indicated on surface by drawing a line from mid-point between zygomatic process (ext. angular) of frontal and external meatus, just above zygoma, to the pterion, and thence towards mid-point between root of nose and ext. occipital protuberance.

Posterior terminal branch runs posteriorly and upwards across squamous temporal; crosses inf. border of parietal about its middle, and ramifies upwards and backwards on cerebral surface of that bone. Its position may be indicated by a line drawn towards lambda from same point above zygoma as given for ant. branch.

Unimportant branches of middle meningeal are **superficial petrosal**, which enters hiatus canalis facialis; **superior tympanic**, which accompanies tensor tympani to tympanum; **orbital**, which passes through sup. orbital fissure and anastomoses with lacrimal.

Inferior alveolar artery (inf. dental) descends between ramus of mandible and speno-mandibular ligament; enters mandibular foramen, accompanied by vein and nerve; runs along mandibular canal and ends at mental foramen by dividing into mental and incisive branches.

Branches.—(1) **Lingual** accompanies lingual n. (2) **Mylohyoid** pierces speno-mandibular lig., descends in mylo-hyoid groove and upon lower surface of mylo-hyoid to anastomose with submental. (3) Branches to gums and *molar, premolar, canine* and *incisor* teeth. (4) **Mental** passes through mental foramen to the face.

(II.) **Branches of Second Part of Int. Maxillary Art.**
 —(1) To **pterygoid muscles**. (2) **Masseteric** passes laterally through mandibular (sigmoid) notch to masseter. (3) **Anterior** and **posterior deep temporal** ascend between temporal muscle and squamous temporal, supplying both. (4) **Buccinator** accompanies buccinator (long buccal) nerve, between temporal and pterygoid muscles, to the buccinator muscle.

(III.) **Branches of Third Part.**—**Posterior superior alveolar** (post. sup. dental descends on infra-temporal surface of maxilla; sends branches to gums and buccinator, and through bone to molars, premolars, and maxillary sinus. **Infra-orbital** passes from pterygo-palatine (spheno-maxillary) fossa to orbit, through inf. orbital fissure. Runs through infra-orbital groove, canal and foramen to the face, accompanied by infra-orb. n. While in floor of orbit it gives branches to orbital structures, maxillary sinus, canine and incisor teeth—*ant. sup. alveolar*.

Descending palatine, having given off the *smaller palatine arteries* (which descend to palate through lesser palatine foramina), becomes the **greater palatine artery**, which traverses greater palatine (B.N.A. pterygo-palatine) canal and foramen, runs forwards on oral surface of hard palate, close to alveolar border, and ends by passing up Stenson's canal in for. incisivum to the nose.

A. canalis pterygoidei (Vidian) runs posteriorly through that canal to upper part of pharynx.

Pharyngeal (pterygo-palatine) runs posteriorly through pharyngeal canal to roof of pharynx.

Spheno-palatine enters nasal cavity through spheno-palatine foramen; supplies mucous membrane of nasal cavity, adjacent sinuses and pharynx. Longest branch crosses roof, descends on septum to anastomose with greater palatine and superior labial.

Internal carotid artery arises at upper border of thyreoid cartilage and lower border of 3rd cerv. vertebra, as branch of bifurcation of common carotid. Ascends in neck in line given for ext. carotid. Traverses carotid canal of temporal, crosses for. lacerum, pierces periosteal layer of dura mater; runs forwards in cavernous sinus on carotid groove of sphenoid; turns up, medial to ant. clinoid process, and ends at anterior perforated substance (spot) by dividing into anterior and middle cerebral arteries, after piercing internal layer of dura mater and the arachnoid.

Relations in Neck.—Enclosed in carotid sheath with jugular vein lateral to it, and vagus between and behind them. Ext. carotid is anterior and medial to it below, and separated from it above by styloid process, stylo-pharyngeus, glosso-pharyngeal n., pharyngeal branches of vagus and sympathetic, pharyngeal veins, and part of parotid.

In carotid triangle sterno-mastoid overlaps it, common facial and lingual veins, hypoglossal nerve and occipital artery cross it, and descendens hypoglossi runs down superficial to it. *Above carotid triangle* it is crossed from below upwards by post. belly of digastric, stylo-hyoid, post. auricular art.; and above that by structures separating

it from ext. carotid. Pharynx, asc. pharyngeal artery and int. and ext. laryngeal nerves are medial to it. *Behind it* are longus capitis, sympathetic trunk, superior laryngeal nerve. *Near base of skull* it is $\frac{1}{4}$ - $\frac{1}{2}$ in. medial to posterior part of mandibular joint, tympanic plate and osseous auditory (Eustachian) tube intervening; cartilaginous part of auditory tube and tensor v. palatini are anterior; levator v. palatini is medial to it; jugular vein, glossopharyngeal, vagus, accessory and hypoglossal nerves are posterior.

No branches in the neck.

Relations in Carotid Canal.—Surrounded by small veins and by branches from superior ganglion of sympathetic. Cochlea and tympanic cavity are posterior and superior; auditory (Eustachian) tube and tensor tympani are anterior and lateral; semilunar ganglion is superior.

Branches in Canal.—**Carotico-tympanic** perforates posterior wall of canal and anastomoses with other arteries in tympanum. **Pterygoid** accompanies greater superficial petrosal nerve.

Relations in Cranium.—In lateral wall of cavernous sinus, endothelium of sinus is medial; oculo-motor, trochlear, ophthalmic and abducent nerves, in wall of sinus, are lateral. It lies between optic and oculo-motor nerves before piercing arachnoid.

Branches in Cranium.—(1) Branches to walls of cavernous sinus and nerves there, to semilunar ganglion, hypophysis (pituitary body), dura mater; (2) ophthalmic; (3) posterior communicating; (4) chorioid; (5) anterior cerebral; (6) middle cerebral.

Ophthalmic artery arises at medial side of ant. clinoid process, after carotid has pierced dura. Runs antero-laterally and enters orbit through optic foramen, below and lateral to optic n. Runs anteriorly a short distance, with rectus lateralis and ciliary ganglion lateral to it. Then crossing between rectus sup. and optic n. to reach medial wall, it runs anteriorly, below obliquus sup., to end at anterior part of orbit in frontal and dorsal nasal arteries. It is accompanied, in orbit, first by naso-ciliary nerve, and next by the infra-trochlear branch of that nerve.

Branches of Ophthalmic Artery.—(a) Long and short posterior ciliary enter posterior aspect of eyeball. (b) **A. centralis retinæ** enters medial side of optic n. and runs in it to retina. (c) **Anterior meningeal** passes into middle cranial fossa through sup. orbital fissure (sphenoidal fissure).

(d) **Lacrimal**, its largest branch, arises on lateral side of optic n.; runs along upper border of rectus lateralis to anterior part of orbit and ends in palpebral and glandular branches. Lacrimal gives branches also to muscles and to eyeball (*anterior ciliary*), and to accompany zygomatic nerve; a *recurrent meningeal branch* passes backwards through sup. orbital fissure.

(e) **Supra-orbital** accompanies supra-orbital n. through supra-

orbital notch to forehead. (*f*) **Anterior** and **posterior ethmoidal** escape through ethmoidal foramina into cranial cavity; supply ethmoidal cells and cavity of nose. (*g*) **Medial palpebral**, to upper and lower eyelids. (*h*) **Rami musculares** to muscles in orbit, from ophthalmic directly and from its branches. They also give branches to eyeball—*anterior ciliary*. (*i*) **A. dorsalis nasi**, to bridge of nose. (*j*) **Frontal** accompanies supra-trochlear nerve to forehead.

Posterior communicating artery arises near end of carotid.

Runs posteriorly below optic tract, in front of cerebral peduncle (*crus cerebri*), above oculo-motor n., and joins posterior cerebral, giving branches to these, and to inter-peduncular structures, uncus, thalamus and int. capsule. **A. chorioidea** arises near end of carotid. Runs backwards between cerebral peduncle and uncus; enters chorioid fissure to end in chorioid plexus of inferior horn of lat. ventricle. Supplies optic tract, basis pedunculi (*crusta*), uncus and post. part of internal capsule, basal ganglia, and ant. commissure.

Anterior cerebral artery runs medially above optic chiasma, in front of lamina terminalis, where it is connected with its fellow by short **anterior communicating art.**; winds round genu of corpus callosum, upon body of which it runs posteriorly to *precuneus*. *Supplies* lamina terminalis, corpus callosum, septum pellucidum, ant. column of fornix, ant. commissure, caudate and lentiform nuclei; *medial surface of hemisphere as far back as parieto-occipital fissure, upper part of lateral surface for corresponding distance, and the gyrus rectus and internal orbital gyrus.*

Middle cerebral artery passes laterally into lateral (Sylvian) fissure of cerebrum, and ends in branches on the surface of insula. Gives **cortical branches** to: 1 lateral half of orbital surface of frontal lobe; 2 ant. end of temporal lobe; 3 *lateral surface of hemisphere*, except a strip, $\frac{1}{2}$ inch or more in breadth, along upper and lower margins; and **central branches**, which pass up through ant. perforated substance and supply caudate and lentiform nuclei, internal capsule, anterior commissure. Most lateral of these pass through perforated substance; groove lateral surface of lentiform nucleus in its lower half; traverse the nucleus and internal capsule and end—the anterior or **lenticulo-striate** in caudate nucleus, the posterior or **lenticulo optic** in thalamus. Largest of lenticulo-striate is called the “artery of cerebral hæmorrhage.”

Vertebral artery arises from first part of subclavian; enters foramen in transverse process of 6th cerv. vertebra, traverses foramina transversaria of upper 6 cervical vert.;

turns dorsally and medially on post. arch of atlas ; pierces dura mater, enters foramen magnum ; and ends at lower border of pons by joining its fellow to form basilar.

Relations.—**First part** is surrounded by sympathetic nerves, and lies between longus colli and scalenus anterior, upon pleura and 7th cervical transverse process, posterior to its own vein and common carotid artery (see also p. 212). **Second part** traverses foramina transversaria, *surrounded* by plexus of nerves from inferior cervical ganglion and plexus of veins, anterior to cervical nerves. **Third part** emerges from for. transversarium of atlas, medial to rectus lateralis, lateral to ant. division of 1st cerv. n. ; passes dorsally and medially, posterior to sup. articular process of atlas, enters groove on post. arch of atlas, where post. branch of 1st cerv. n. lies between it and bone ; passes into vertebral canal in front of post. atlanto-occipital membrane. **Fourth part** pierces dura mater, enters cranial cavity through for. magnum, pierces arachnoid and runs upwards and medially on lateral and anterior surfaces of medulla oblongata to median plane, at lower border of pons.

Branches of Vertebral Artery.—Muscular, from 1st, 2nd, 3rd parts. **Rami spinales**, from 2nd part, pass through intervertebral foramina to reinforce spinal arteries. **Anastomotic**, from 3rd part, to anast. with profunda cervicis and descending branch of occipital. *From 4th part*—(1) **Meningeal branches**, to posterior cranial fossa. (2) **Posterior spinal** runs downwards and divides into branches, which lie both in front of and behind post. nerve roots. (3) **Anterior spinal** unites with its fellow on anterior surface of medulla oblongata to form a single artery, which runs down in front of ant. median fissure of spinal medulla. (4) **Posterior inferior cerebellar** arises near end of vertebral, runs obliquely backwards around medulla oblongata into vallecule cerebelli, where it divides into *medial* and *lateral branches*, supplying vermis and inf. surface of hemisphere. (5) **Small branches to medulla oblongata**.

Basilar artery is formed at lower border of pons by union of vertebrals ; runs upwards in relation to dorsal surface of upper part of basi-occipital and of dorsum sellæ, in the groove on ventral surface of pons, to end at its upper border by dividing into two posterior cerebral arteries.

Branches.—(1) **Rami ad pontem**. (2) **Internal auditory** accompanies acoustic nerve. (3) **Anterior inferior cerebellar** passes backwards to anterior part of inf. surface of cerebellar hemisphere. (4) **Superior cerebellar** arises near end of basilar, runs along upper border of pons and lateral surface of basis pedunculi (crusta), below oculo-motor and trochlear nerves, to ramify on upper surface of cerebellar hemisphere.

Posterior cerebral artery arises at upper border of pons, as a branch of bifurcation of basilar; runs posteriorly and upwards between basis pedunculi and uncus, above oculo-motor and trochlear ns., to calcarine fissure, to end in cortical branches there. It is connected with int. carotid by post. communicating. **Branches:** **cortical branches**, to tentorial surface of hemisphere (except ant. end of temporal lobe) and adjoining part of convex surface, post. part of medial surface, including post. $\frac{1}{2}$ inch of præcuneus, and adjoining part of convex surface; **central branches**, to corpus mamillare, basis pedunculi, nucleus ruber, thalamus, corpora geniculata, fornix, and chorioid plexus.

Circulus arteriosus (circle of Willis) is situated in subarachnoid space at base of brain, enclosing the optic chiasma and the structures in the inter-peduncular fossa. It is formed by point of bifurcation of basilar, two post. cerebrals, two post. communicating, two int. carotids, two ant. cerebrals, and ant. communicating.

Relations. passing from posterior to anterior limit of circle. **Within the circle** are the post. perforated substance, corpora mamillaria, tuber cinereum and infundibulum; lamina terminalis and optic chiasma. **Above it** are the posterior perforated substance, basis pedunculi (crusta), optic tract, anterior perforated substance, posterior end of gyrus rectus and medial stria of olfactory tract, rostrum of corpus callosum, and longitudinal fissure. **Below it** are the dorsum sellæ, attached margin of tentorium cerebelli near posterior clinoid process, cavernous sinus, optic chiasma.

Circumferentially it is related to upper border of pons, basis pedunculi (crusta), oculo-motor nerve and uncus, beginning of stem of lateral fissure of cerebrum (Sylvius), gyrus rectus, longitudinal fissure of cerebrum. (Oculo-motor nerve is first posterior to posterior cerebral artery, behind its anastomosis with post. communicating, and then turns anteriorly beneath post. cerebral to lie between post. communicating and uncus.)

Cortical branches of cerebral arteries anastomose freely in the pia mater, but very little, if at all, after entering brain substance; and the central branches do not anastomose at all.

Left subclavian artery arises from aortic arch, behind and to left of carotid, at left side of trachea; ascends to root of neck; arches laterally behind scalenus anterior, over anterior aspect of dome of pleura and over 1st rib, to end at outer border of 1st rib by becoming continuous with axillary.

Divided into 3 parts: (1) from origin to medial border of scalenus ant.; (2) behind scalenus ant.; (3) from lateral

border of scal. ant. to ext. border of 1st rib. Position in neck may be indicated by an arched line, convex upwards, drawn from sterno-clavicular joint to middle of clavicle, highest point of arch being $\frac{1}{2}$ to 1 inch above clavicle.

Relations of First Part.—(a) *In thorax*: *Anterior and to the right*: vagus and phrenic ns., cervical cardiac branches of left vagus and sympathetic, left common carotid. Left pleura and lung overlap. *Right side*: trachea, recurrent n., œsophagus, from below upwards. *Left side*: pleura and lung. *Posterior*: œsophagus, thoracic duct, longus colli medially; pleura and lung laterally. (b) *In root of neck*: *Anterior*: vertebral, internal jugular and innominate veins, vagus and phrenic nerves; sterno-thyreoid and sterno-hyoid. *Posterior and inferior*: pleura and lung. Thoracic duct ascends posterior to it at side of œsophagus, descends anterior to it at medial margin of scalenus anterior.

Second Part is the highest part of arch— $\frac{1}{2}$ to 1 inch above clavicle—and lies between scalenus anterior and pleura. See also pp. 212, 217.

Relations of Third Part.—*Anterior*: n. to subclavius; transverse scapular (supra-scapular) art. and vein, transverse cervical and ext. jugular veins; subclavian vein on lower level; clavicle and subclavius. *Posterior*: lowest trunk of brachial plexus; scalenus medius. First rib is *below* and posterior. See also p. 204.

Right subclavian artery begins behind upper part of sterno-clavicular joint. Arches laterally across dome of pleura to end at outer border of 1st rib. Subdivided, in same way as left, into 3 parts.

Relations of First Part (see also pp. 212, 216).—*Anterior*: vagus, vertebral vein; int. jugular vein; sterno-thyreoid and sterno-hyoid. *Posterior and inferior*: recurrent nerve; pleura and lung.

Relations of second and third parts are as those of left, except that phrenic nerve, on right side, is in front of 2nd part, separated from it by scalenus anterior.

Branches are alike on both sides: vertebral (pp. 212, 273), thyreo-cervical trunk; int. mammary; costo-cervical trunk.

Thyreo-cervical trunk (thyroid axis) arises near medial border of scalenus anterior; runs upwards for $\frac{1}{6}$ inch upon cervical pleura, behind int. jugular vein, and divides into inferior thyreoid, transverse cervical and transverse scapular (supra-scapular) arteries.

Inferior thyroid artery (see also p. 211) runs upwards to level of cricoid, and then medially, behind carotid sheath, anterior to vertebral artery, to reach thyroid gland; and turns downwards to its lower end to divide into inferior and ascending terminal branches.

Branches.—(a) **Ascending cervical** runs upwards on transverse processes, between origins of longus capitis and scalenus ant.; supplies these and sends spinal branches in through intervertebral foramina. (b) **Inferior laryngeal** accompanies inferior laryngeal nerve, under lower border of inf. constrictor, into larynx. (c) **Muscular branches** to adjacent muscles. (d) **Tracheal, œsophageal and terminal glandular** (thyreoid) branches.

A. transversa scapulæ (**transverse scapular**, supra-scapular) runs laterally and dorsally across root of neck, *deep* to sterno-mastoid, clavicle and trapezius, *superficial* to scalenus anterior, phrenic nerve, 3rd part of subclavian artery and brachial plexus, to reach the upper border of scapula, where it crosses transverse lig., enters supra-spinous fossa, gives off a branch there, and descends through great scapular notch to end in infra-spinous fossa. See also p. 205.

A. transversa colli (**transverse cervical**) runs laterally, dorsally and upwards, *deep* to sterno-mastoid and omo-hyoid, *superficial* to scalenus anterior, phrenic nerve and trunks of brachial plexus, to reach anterior border of levator scapulæ, where it divides into ascending and descending rami (see also p. 205). **R. ascendens** (**superficial cervical**) crosses levator scapulæ and splenius, and ramifies on deep surface of trapezius. **R. descendens** (**posterior scapular**) may arise from 3rd part of subclavian, descends along vertebral border of scapula, *deep* to levator and rhomboids, and anastomoses with other scapular arteries and with intercostals.

Internal mammary artery arises at medial border of scalenus anterior; runs downwards, forwards, and medially to 1st costal cartilage; then vertically behind costal cartilages, $\frac{1}{2}$ inch from side of sternum; ends opposite 6th intercostal space by dividing into superior epigastric and musculo-phrenic. **Relations.**—**In neck:** *Anterior:* int. jugular and origin of innominate vein; clavicle. Phrenic nerve crosses it obliquely, latero-medially, before it enters thorax. *Posterior:* pleura. **In thorax:** *Anterior:* costal cartilages, internal intercostal muscles; intercost. nerves. *Posterior:* transversus thoracis (triangularis sterni); pleura. *On each side:* vena comitans.

Branches.—(a) **Pericardiaco-phrenic** (comes nervi phrenici) accompanies phrenic n. and supplies pericardium, pleura and diaphragm. (b) **Anterior mediastinal**, to areolar tissue, thymus and pericardium. (c) **Rami intercostales**, two to each of upper 6 spaces, pierce int. intercostal and anastomose with superior and aortic intercostals. (d) **R. perforantes** pierce int. intercostal, ant. intercost. membrane, pectoralis major and its fascia to reach skin. Those in 3rd and 4th spaces send branches to mammary gland.

(e) **Musculo-phrenic artery** passes down between attachments of diaphragm to 7th and 8th, or 8th and 9th cartilages, and runs laterally along attachment of diaphragm as far as 10th cartilage. *Supplies* muscles and sends two branches into each of 7th, 8th, 9th intercostal spaces. (f) **Superior epigastric artery** descends between xiphoid and costal origins of diaphragm, enters sheath of rectus and ends in substance of rectus. **Branches:** **muscular**, **cutaneous**; and **hepatic**, which runs along falciform ligament. *Anastomoses* with inf. epigastric, arteries accompanying lower intercostal nerves, hepatic artery.

Costo-cervical trunk (superior intercostal) arises from 1st part of subclavian at medial border of scalenus anterior on left side, but *from 2nd part of subclavian on right side*; passes upwards and posteriorly over apex of pleura, behind scalenus ant., to neck of 1st rib, where it divides into: (1) **A. intercostalis suprema** (sup. intercostal), which descends anterior to neck of 1st rib, and ends in two branches distributed, in first two spaces, like aortic intercostals. (2) **A. cervicalis profunda** (deep cervical), which runs dorsally between neck of rib and 7th cervical transverse process, and upwards between semispinalis cervicis and s. capitis (complexus) to anastomose with descending branch of occipital.

Usually no branch from 3rd part of subclavian.

Axillary artery begins at outer border of 1st rib as continuation of subclavian; arches laterally and distally through axilla to end at lower border of teres major tendon by becoming brachial; but its course varies with position of arm. When arm is abducted to a right angle, artery lies in a line drawn from middle of clavicle to junction of lower border of posterior wall of axilla with arm.

Divided into 3 parts. **1st part**, from border of rib to upper border of pectoralis minor (exists only when pect. minor is loosened and pulled down by dissection). **2nd part** is posterior to pect. minor. **3rd part**, from lower border of pect. minor to lower border of teres major, is longer than the other two parts together.

Relations of 1st Part (see also p. 130).—*Enveloped*, with vein and cords of brachial plexus, in fascial sheath. *Anterior*: cephalic vein; costo-coracoid membrane; pectoralis major. *Lateral and above*: lateral and post. cords of plexus. *Medial and below*: axillary vein. *Posterior*: medial cord of plexus, long thoracic nerve; 1st intercostal space, 1st digitation of serratus anterior (magnus).

Of 2nd Part.—*Anterior*: pectoralis minor and major. *Lateral*: lateral cord of plexus. *Medial*: medial cord; axillary vein. *Posterior*: posterior cord; subscapularis.

Of 3rd Part.—*Anterior*: medial head of median nerve, medial cutaneous nerve of forearm; pectoralis major proximally, only fasciæ and skin distally. *Lateral*: median and musculo-cutaneous nerves. *Medial*: ulnar n.; axillary vein; medial cutaneous nerve of arm (lesser int. cutaneous). *Posterior*: radial (musculo-spiral) n., axillary (circumflex) n.; subscapularis, latissimus dorsi, teres major.

Branches.—**First part**: thoracalis suprema. **Second part**: thoraco-acromial or acromio-thoracic, lateral thoracic, alar thoracic. **Third part**: subscapular; anterior and posterior humeral circumflex.

Art. thoracalis suprema ramifies over 1st intercostal muscle.

Thoraco-acromial artery (thoracic axis) turns over upper border of pect. minor, pierces costo-coracoid membrane, divides into branches:—*a*) **Clavicular** runs medially, deep to pect. major. *b*) **Pectoral** descends between pect. major and minor. *c*) **Acromial** runs across pect. minor and coracoid process and pierces deltoid. *d*) **Deltoid** runs distally between pect. major and deltoid.

Lateral thoracic art. runs downwards and medially along lower border of pect. minor to wall of thorax; supplies muscles and mammary gland. **Alar thoracic** are small branches to fat and lymph glands.

Subscapular art. runs along lower border of subscapularis to inf. angle of scapula and supplies adjacent muscles, and gives off **a. circumflexa scapulæ** (dorsalis scapulæ), which reaches dorsum of scapula by passing under teres minor. **Art. circumflexa humeri anterior** (anterior humeral circumflex) runs laterally, anterior to surgical neck of humerus, and sends branches proximally and distally in intertubercular (bicipital) groove. **Art. circumflexa humeri posterior** (post. humeral circumflex), much larger, passes dorsally through quadrilateral space, winds round surgical neck under cover of deltoid. Its most important anastomosis is with profunda of brachial.

Brachial artery begins, as the continuation of axillary, at lower border of teres major tendon; runs distally and slightly laterally to end in cubital fossa, antero-medial to neck of radius, by dividing into radial and ulnar.

Relations.—Lies superficially, medial to humerus proximally, in front of it distally. Coraco-brachialis is on lateral side and overlapping, but is posterior to artery at insertion. Biceps is lateral and overlapping, and sends lacertus fibrosus (bicipital fascia) medially in front of it at elbow. Triceps (long and medial heads), coraco-brachialis and brachialis are posterior to it, in that order proximo-distally.

Median n., at first lateral, crosses it in middle of arm to run along medial side. Ulnar n. is on medial side as far as middle of arm, where it deviates from it postero-medially. Medial cutaneous nerve of forearm (int. cutaneous) is anterior to it at origin, then on medial side as far as middle of arm, where it leaves it by piercing deep fascia. Radial (musculo-spiral) n. is posterior to its first inch and separates it from long head of triceps.

Profunda art. and vein also are between it and long head of triceps. Venæ comites accompany it. Median basilic vein crosses it at elbow, separated by lacertus fibrosus (bicipital fascia). Basilic vein pierces deep fascia about middle of arm, and runs towards axilla along its medial side.

Branches.—Profunda brachii, superior ulnar collateral, nutrient, inferior ulnar collateral, unnamed muscular branches, and terminal branches.

A. profunda brachii (sup. profunda) arises near origin of brachial, anastomoses with post. humeral circumflex, accompanies radial (musculo-spiral) n. to posterior aspect of humerus, gives *muscular* branches and a *nutrient* to humerus, and divides into anterior and posterior terminal branches. **Anterior branch** accompanies radial nerve to ant. aspect of lateral epicondyle and anastomoses with radial recurrent. **Posterior branch** runs to post. aspect of epicondyle to anastomose with dorsal interosseous recurrent. **Superior ulnar collateral artery** (inferior profunda) arises at insertion of coraco-brachialis and accompanies ulnar n. to post. aspect of medial epicondyle to anastomose with dorsal ulnar recurrent. **Art. nutricia humeri** (**Nutrient**) arises near sup. ulnar collateral and enters humerus. **Inferior ulnar collateral art.** (anastomotica magna) arises proximal to elbow, runs medially upon brachialis; divides into **anterior branch**, which anast. with volar ulnar recurrent, and **posterior branch**, which pierces medial

intermuscular septum and anast. with sup. ulnar collateral and dorsal ulnar recurrent.

Radial artery arises in cubital fossa, antero-medial to neck of radius, as a branch of bifurcation of brachial; runs distally, with inclination laterally, to apex of styloid of radius; then curves round lateral and dorsal aspects of wrist to reach proximal end of 1st intermetacarpal space; thence through intermetacarpal space into palm to end as deep volar arch. It is accompanied by venæ comites.

First Part.—**Relations:** *Anterior:* overlapped by brachio-radialis proximally, superficial distally. *Dorsal to it,* in succession, are biceps tendon, supinator, pronator teres insertion, flexor digitorum sublimis, flexor pollicis longus, pronator quadratus, distal end of radius. *Lateral:* superficial branch of radial nerve, brachio-radialis. *Medial:* pronator teres, flexor carpi radialis. **Branches:** radial recurrent, superficial volar, volar carpal, unnamed muscular.

Radial recurrent arises near origin of radial, runs proximally to anastomose with ant. branch of profunda. **Superficial volar** arises near wrist, ends in muscles of ball of thumb, or may complete superficial volar arch. **R. carpeus volaris (Volar radial carpal)** runs medially on distal end of radius.

Second part *lies upon* collateral radio-carpal lig., os naviculare and multangulum majus (trapezium); *crossed by* tendons of abductor longus and ext. brevis and longus of thumb. **Third part** passes to palm between heads of 1st dorsal interosseous muscle, and between the two portions of adductor pollicis.

Branches of Second Part.—(1) **Dorsales pollicis** run distally, one on each side of thumb. (2) **Dorsalis indicis** runs along lateral side of index. (3) **R. carpeus dorsalis (Dorsal radial carpal)** runs medially on distal row of carpus to join similar branch of ulnar to form **dorsal carpal arch**, from which 3 **dorsal metacarpal arteries** run distally over 2nd, 3rd and 4th inter-metacarpal spaces; they anastomose with arteries in palm by means of proximal and distal *perforating arteries*.

Branches of Third Part.—**A. princeps pollicis** runs to the thumb, dividing into two branches. **A. volaris indicis radialis (Radialis indicis)** runs to radial margin of index.

Ulnar artery begins as branch of bifurcation of brachial in cubital fossa, antero-medial to neck of radius; runs in proximal

$\frac{1}{3}$ of forearm distally and medially, in remainder, vertically, to end at ulnar side of hook of os hamatum (unciform) by dividing into superficial volar arch and deep volar branch.

Relations.—Venæ comites accompany it. Distal two-thirds superficial. Ulnar n. approaches it, and lies close to ulnar side in distal two-thirds; palmar cutaneous branch of ulnar nerve descends on its anterior surface in distal $\frac{1}{3}$ of forearm. Median nerve, medial to it at first, crosses it, separated from it by ulnar head of pronator teres. Flexor carpi ulnaris lies along its medial side, overlapping it proximally. Flexor sublimis is lateral to it distally. Pronator teres, flexor carpi uln., palmaris longus, flexor sublimis cross it in proximal part of forearm; volar carpal ligament and palmaris brevis cross it at wrist and palm. Brachialis, flexor profundus, transverse carpal lig. (ant. annular), lig. piso-hamatum (piso-unciform lig.), hook of os hamatum (unciform) are dorsal to it, in that order from cubital fossa to palm.

Branches.—Volar ulnar recurrent, dorsal ulnar recurrent, common interosseous, volar and dorsal ulnar carpal, and the terminals.

Volar ulnar recurrent artery runs proximally to anterior aspect of medial epicondyle, to anast. with ant. branch of inf. ulnar collateral (anastomotic).

Dorsal ulnar recurrent artery runs between flexor sublimis and profundus and between heads of flexor carpi uln. to post. aspect of epicondyle, to anast. with sup. and inf. ulnar collateral.

Volar ulnar carpal arises from ulnar, proximal to transverse carpal lig.; passes laterally, deep to flexor tendons, to unite with similar branch of radial to form **volar carpal arch**. See also p. 150.

Dorsal ulnar carpal turns dorsally and distally under cover of flex. and ext. carpi ulnaris and unites with similar branch of radial. See also p. 154.

Common interosseous artery arises, distal to recurrent, an inch from origin of ulnar, and almost at once divides into volar and dorsal interosseous branches. **Volar interosseous artery** runs distally upon volar surface of interosseous membrane, between flexor profundus and flexor pollicis, accompanied by venæ comites and volar inteross. n., to proximal border of pronator quadratus, where it pierces interosseous membrane and descends upon its dorsal surface and dorsum of radius and wrist to join dorsal carpal arch.

Branches.—*Median* accompanies median n.; *nutrient*, to

radius and ulna; *muscular*; *anterior communicating* runs posterior to pronator quadratus to join volar carpal arch.

Dorsal interosseous artery passes dorsally between chorda obliqua and interosseous membrane, and appears on dorsum between supinator and abductor pollicis longus; runs distally between superficial and deep muscles, and ends by anast. with volar interosseous and dorsal carpal arch. Venæ comites accompany it. Dorsal interosseous n. is on radial side at first, but is separated distally by extensor poll. longus and ext. indicis proprius.

Branches: (1) *Interosseous recurrent* runs to post. aspect of lateral epicondyle to anastomose with post. branch of profunda. It lies on supinator and is covered by ext. carpi ulnaris and anconeus. (2) *Muscular and cutaneous*.

Ramus volaris profundus (deep branch of ulnar) runs distally, dorsally and laterally between muscles of little finger and joins deep volar arch. See also p. 150.

Superficial volar or palmar arch arches across palm, under cover of palmar aponeurosis, from ball of little finger to ulnar border of flex. poll. brevis, where it is completed by superficial volar of radial, or princeps pollicis, or radialis indicis. Convexity of arch reaches line drawn transversely from distal border of abducted thumb. It gives off four **common volar digital arteries**. The first runs to ulnar side of little finger. The other three run towards the webs and divide into *proper volar digital arteries* for contiguous sides of the four fingers. See also p. 150.

Deep volar or palmar arch, formed by radial, extends from interval between heads of adductor pollicis across interossei, just distal to bases of 3rd and 4th metacarpals, to base of 5th, where it is joined by profunda of ulnar. It lies $\frac{1}{2}$ inch nearer wrist than superficial arch. **Branches**: (a) *recurrent*, to anastomose with volar carpal arch. (b) Three *proximal perforating*, to join dorsal metacarpals. (c) Three *volar metacarpal* run distally to join common volar digitals.

BRANCHES OF DESCENDING THORACIC AORTA

Intercostal, subcostal, bronchial, superior phrenic to diaphragm (very small), 4 or 5 cesophageal, pericardial and mediastinal to pericardium, areolar tissue and lymph glands in post. mediastium.

Intercostal arteries, 9 pairs for lower 9 intercostal spaces,

arise from aorta, run to intercostal spaces, posterior to splanchnic nerves and sympathetic trunk, upon bodies of vertebræ and ant. costo-transverse lig. On right side they all pass posterior to thoracic duct and vena azygos, while upper 5 pass posterior to œsophagus also. On left side they pass posterior to v. hemiazygos and hemiaz. accessoria. In intercostal space the vein is above, nerve below. At angle of rib each artery slips in between ext. and int. intercostal muscles and runs in costal groove and anast. with branch of int. mammary or musculo-phrenic. In front of angle it gives off *collateral branch*, which descends and runs along upper border of rib below. Last two intercostals accompany nerves into abdominal wall.

Branches.—(1) **Posterior branch** accompanies post. branch of thoracic nerve through interval medial to ant. costo-transverse lig.; sends **spinal branch** in through intervertebral foramen; divides into **medial and lateral branches** to supply skin and muscles of back. (2) **Collateral branch** described above. (3) **Lateral cutaneous branch** accompanies lateral cutaneous nerve to skin. (4) **Muscular branches.** (5) **Branches to mammary gland** from upper 3 or 4. (6) **Right bronchial** from 1st.

Anastomoses.—With one another; with superior intercostal, subcostal, mammary, musculo-phrenic, inferior phrenic, lumbar, epigastric, spinal, transverse cervical, thoracalis suprema and lateral thoracic.

Subcostal, one pair, passes into abdomen, posterior to lateral lumbo-costal arch (ext. arcuate lig.) in front of quadratus, pierces transversus abdominis and accompanies last thoracic nerve in ant. abdominal wall.

Left Bronchial Arteries.—Two, from near origin of descending aorta, run laterally and downwards to left bronchus and accompany it into lung. **Right bronchial artery** arises from 1st right aortic intercostal or upper left bronchial or aorta, and crosses œsophagus to reach right bronchus.

BRANCHES OF ABDOMINAL AORTA

Inferior phrenic arteries arise near beginning of abdominal aorta. Each passes upwards and laterally on corresponding crus, the *right* behind vena cava, the *left* behind œsophagus; and each ramifies on abdominal surface of diaphragm, and gives a *superior suprarenal* branch to suprarenal gland.

Lumbar arteries, 4 pairs, arise from dorsal aspect of aorta,

run laterally and dorsally on bodies of upper 4 L. vertebrae, posterior to sympathetic trunk, psoas major (from which they are separated by tendinous arches) and lumbar plexus, to interval between transverse processes. Upper two, on each side, are posterior to crus of diaphragm also. Lower two right are posterior to vena cava, upper two right are posterior to cisterna chyli and vena azygos. Each gives off a **dorsal branch** to accompany post. branch of lumbar nerve, and then proceeds laterally, the upper three behind quadratus lumborum, lowest often in front of it; pierce transversus and run anteriorly in abdominal wall between transversus and obliquus int.

Anastomose with intercostals, subcostal, epigastrics, deep circumflex iliac, ilio-lumbar, and, by minute twigs in subperitoneal plexus, with hepatic, renal, and colic.

Middle sacral artery arises from dorsal aspect of aorta, $\frac{1}{2}$ inch above bifurcation; descends on anterior aspect of lower two L. vertebrae, sacrum and coccyx to end in branches to glomus coccygeum (coccygeal body). **Relations**: Venae comites. *Anterior* to it are aorta; left common iliac vein; peritoneum and coils of intestine; rectum. **Branches**: 5th lumbar pair pass laterally on side of 5th L. vert. and anast. with ilio-lumbar. Small branches pass to rectum; others anastomose with lateral sacral.

Middle suprarenal arteries arise opposite superior mesenteric. Each passes upwards and laterally on crus of diaphragm to reach suprarenal gland. Pancreas is anterior to both, and inferior v. cava also is anterior to right artery.

Renal artery arises from side of aorta below sup. mesenteric, opposite upper border of 2nd L. vertebra; passes laterally on crus and psoas, and enters hilum of kidney. *Left* lies posterior to renal vein and pancreas and termination of duodenum; *right* is longer and is posterior to renal vein, vena cava, head of pancreas, and descending part of duodenum. **Branches**: (1) Three to kidney, two anterior to pelvis, one dorsal to it. (2) *A. suprarenalis inferior* to suprarenal gland. (3) To ureter. (4) To lymph glands and perinephric fat.

Internal spermatic artery arises from ant. aspect of aorta, below renal. Runs downwards and laterally to abdominal inguinal ring, traverses inguinal canal, descends tortuously in spermatic cord, anterior to ductus deferens; divides at upper end of testis to supply testis and epididymis. **Relations** in abdomen: *accompanied* by spermatic veins.

Right artery *lies upon* aorta, vena cava, ureter, genito-femoral nerve, psoas, ext. iliac art. *Covered* by peritoneum, and *crossed anteriorly* by 3rd part of duodenum, right colic, ileo-colic, end of sup. mesenteric vessels, root of mesentery, end of

ileum, and vermiform process. **Left artery** *lies upon* aorta, sympathetic trunk, ureter, genito-femoral n., psoas, ext. iliac art. *Covered by* peritoneum, and *crossed by* left colic and sigmoid vessels, and iliac colon. At abd. inguinal ring each artery meets ductus deferens and turns round inf. epigastric artery. **Branches**: to ureter, to cremaster. *Epididymal* branch supplies epididymis and anastomoses with artery to ductus deferens. *Testicular* branches enter back of testis.

Ovarian artery is the internal spermatic of the female, and has same relations as in male down to margin of pelvis, where it turns medially over upper part of ext. iliac vessels, enters broad ligament to reach ovary. Gives branches also to ureter, uterine tube, ligamentum teres, and uterus.

Cœliac artery arises from anterior aspect of first $\frac{1}{2}$ inch of abdominal aorta, runs horizontally forwards for $\frac{1}{2}$ inch, across lower border of caudate (spigelian) lobe of liver, and upper border of pancreas, and divides into left gastric, splenic and hepatic branches. **Relations**: *surrounded by* cœliac plexus; median arcuate ligament and caudate lobe *above*; crus of diaphragm and cœliac ganglion *on each side*; pancreas and splenic vein *below*. Omental bursa (lesser sac), separating it from liver or lesser omentum, *in front*.

Left gastric artery (coronary), the smallest, runs up and to the left on left crus, behind omental bursa, to œsophageal end of stomach; sends **œsophageal branches** through hiatus œsophageus; turns down over upper border of omental bursa (lesser sac), and runs along lesser curvature of stomach, between layers of lesser omentum, on ant. surface of omental bursa, giving branches to both surfaces of stomach; ends by anastomosing with right gastric (pyloric).

A. lienalis (splenic), the largest, runs to left and upwards, tortuously, along upper border of pancreas, upon left crus, suprarenal and kidney, dorsal to omental bursa and stomach, and divides into 5-8 splenic branches. Splenic vein lies below it, dorsal to pancreas. **Branches**: (a) **Rami lienales (splenic)** pass through lieno-renal ligament and enter hilum on gastric surface of spleen. (b) **Pancreatic**. (c) **Aa. gastricæ breves** (vasa brevia), 5 or 6 run between layers of gastro-splenic lig. (omentum) to fundus of stomach. (d) **Left gastro-epiploic artery** arises near spleen, runs in gastro-splenic ligament to left end of stomach, and then along greater curvature, between 2 ant. layers of greater omentum, giving branches

to both surfaces of stomach, and some to anast. with middle colic ; ends by anastomosing with right gastro-epiploic.

Hepatic artery runs to the right, along upper border of pancreas, to 1st part of duodenum ; then forwards below for. epiploicum (Winslow), and lastly upwards in front of for. epiploicum, between layers of lesser omentum, near free border, anterior to portal vein, on left side of bile duct, to reach porta hepatis, where it divides into right and left hepatics. **Branches:** (a) **Right gastric** (pyloric) runs to the left along lesser curvature, between layers of lesser omentum ; gives branches to both surfaces of stomach ; ends by anast. with left gastric. (b) **Gastro-duodenal** descends posterior to 1st part of duodenum and ends at its lower border by dividing into : (i.) *sup. pancreatico-duodenal*, which runs to the right and then downwards between duodenum and pancreas, supplying both and anast. with inf. pancreatico-duod. ; and (ii.) *right gastro-epiploic*, which runs to left along greater curvature, between ant. layers of greater omentum, sending branches to both surfaces of stomach, and some to anast. with middle colic ; ends by anast. with left gastro-epiploic. (c) **Right and left hepatic branches** enter porta and sink into liver. In porta they lie posterior to hepatic ducts, anterior to branches of portal vein. Right branch gives *cystic* branch downwards to gall-bladder.

Superior mesenteric artery arises from ant. aspect of aorta below coeliac, posterior to pancreas, opposite 1 L. vertebra, in or just below transpyloric plane ; crosses 3rd part of duodenum, enters mesentery and takes curved course, convexity to left, and ends in right iliac fossa by anastomosing with its own ileo-colic branch.

Relations. Its vein on its right side. *Anterior* : body of pancreas, splenic vein, peritoneum of mesentery, coils of small intestine. *Posterior* : left renal vein, uncinatè process of pancreas, 3rd part of duodenum, aorta, vena cava, right ureter, psoas, genito-femoral nerve and spermatic vessels.

Branches : (1) **Inf. pancreatico-duodenal** runs to the right between pancreas and duodenum, and supplies both, anast. with sup. pancreat.-duod. (2) **Aa. intestinales jejunaes, ileæ** (*vasa intestini tenuis*), 12-15, arise from convexity, run towards small intestine between layers of mesentery, divide and anastomose, forming *arterial arcades*, from which small vessels spring, divide and anastomose, and so on till 3-5 series of arcades are formed before intestine is reached.

(3) **Middle colic artery** arises at lower border of pancreas, enters transverse mesocolon, in which it runs downwards and anteriorly to supply trans. colon ; divides into right and left branches, which anast. with right and left colics, and with right and left gastro-epiploics.

(4) **Right colic artery** arises below duodenum, runs to the right, under cover of peritoneum, across vena cava, spermatic vessels, ureter and psoas (often higher up, across duodenum and kidney), to supply ascending colon. Divides into ascending and descending branches to anast. with middle colic and ileo-colic, respectively.

(5) **Ileo-colic artery** arises either with preceding, or independently below it ; runs to the right, under cover of peritoneum, across vena cava, spermatic vessels, ureter and psoas ; divides into (i.) *ascending branch*, which anast. with right colic and supplies asc. colon, and (ii.) *descending*, which anast. with end of sup. mesenteric, and gives branches to ileum and cæcum, and an *appendicular art.*, which runs to vermiform process behind end of ileum and through mesentery of vermiform process.

Inferior mesenteric artery arises from left side of ant. aspect of aorta, $1\frac{1}{2}$ inches above bifurcation ; runs down and to the left, behind peritoneum ; in front of aorta and sympathetic trunk, across common iliac art. and ends there as superior hæmorrhoidal. Its vein is to left side, some distance away.

Branches : (1) **Left colic artery** arises near origin, runs to left, behind peritoneum and inf. mesent. vein, across sympathetic trunk, ureter, left spermatic vessels and psoas ; divides into two : (a) *ascending branch* crosses lower end of left kidney, enters trans. mesocolon, supplies left colic flexure and trans. colon, and anast. with middle colic ; (b) *descending branch* supplies desc. colon, and anast. with sigmoid arteries.

(2) **Sigmoid arteries**, 2 or 3, run down and to the left, behind peritoneum and inf. mesenteric vein ; across psoas, ureter, and spermatic vessels ; supply iliac and pelvic cola. Upper anast. with left colic ; lower enter pelvic mesocolon, crossing common iliac vessels, and anast. with sup. hæmorrhoidal.

(3) **Superior hæmorrhoidal artery**, the continuation of inf. mesenteric, enters pelvic mesocolon, runs half way down posterior surface of rectum, divides into two branches, which run down on the sides of rectum and sink into its substance. Anast. with mid. and inf. hæmorrhoidal.

Common iliac arteries begin, at left side of body of 4th l. vertebra, as branches of bifurcation of aorta. Each runs downwards and laterally, and ends at level of lumbo-sacral fibro-cartilage, opposite sacro-iliac joint, by dividing into hypogastric and external iliac. Right artery is about 2 inches long; left art., $1\frac{3}{4}$ inches. Upper $\frac{1}{3}$ of line drawn from point $\frac{1}{2}$ inch to left and below umbilicus to point midway between ant. sup. iliac spine and symphysis pubis, corresponds to common iliac, and lower $\frac{2}{3}$ corresponds to external iliac.

Relations.—*Anterior*: peritoneum and coils of intestine, sympathetic nerves connecting aortic with hypogastric plexus; near termination, ureter very often; sup. hæmorrhoidal vessels also lie on left art. *Posterior*: bodies of 4th and 5th l. vertebrae and fibro-cartilage between; sympathetic trunk; psoas; and some distance away, obturator n., lumbo-sacral trunk and ilio-lumbar art. Right artery is separated from all these (except at lower end where it touches psoas) by termination of right and left common iliac veins and origin of vena cava. Left common iliac vein is medial to its artery.

Branches.—None of consequence except terminals.

Hypogastric artery (Internal iliac) arises, as terminal branch of common iliac, on medial border of psoas; runs downwards and posteriorly into pelvis for $1\frac{1}{2}$ inches, to end near upper border of greater sciatic notch, by breaking up into anterior and posterior divisions. Smaller in adult than ext. iliac, but twice as large in fœtus, where it runs to umbilicus and thence to placenta as umbilical artery. After birth, part from pelvis to umbilicus becomes fibrous cord—lateral umbilical lig. or obliterated umbilical art. obliterated hypogastric—pervious only up to point where it gives off vesical art.

Branches of posterior division: ilio-lumbar, lateral sacral and superior gluteal. **Branches of anterior division**: (1) **Visceral**: superior vesical (given off by obliterated umbilical; middle hæmorrhoidal; and, *in male*, inferior vesical; *in female*, vaginal and uterine. (2) **Parietal**: obturator, internal pudendal, inferior gluteal.

Relations.—*Anterior*: ureter and peritoneum, and in female, in addition, the ovary and uterine tube, separated by peritoneum. *Posterior*: its vein, origin of common iliac vein; lumbo-sacral trunk, sacrum. *Medial*: peritoneum separates it from ileum on right side, from pelvic colon on left. *Lateral*: ext. iliac vein, obturator nerve and vein; psoas.

Ilio-lumbar artery runs upwards and laterally, between obturator n. and lumbo-sacral trunk, behind common iliac art., psoas, iliacus, supplying them. It sends a **lumbar branch** upwards behind psoas, which sends *spinal branch* through lumbo-sacral intervertebral foramen. Its vein ends in common iliac.

Lateral sacral arteries, 1 or 2 branches, run downwards and medially, divide and enter 4 anterior sacral foramina, supply structures in sacral canal, emerge through post. sacral foramina, and anastomose with gluteal arteries.

Superior gluteal artery is continuation of post. division of hypogastric; pierces pelvic fascia, passes posteriorly between lumbo-sacral trunk and 1st sacral n., leaves pelvis through upper part of greater sciatic notch, above piriformis; appears in buttock under cover of glutæus maximus, between glut. medius and piriformis; divides into two: (a) **superficial division** sinks into glutæus maximus; (b) **deep division** runs anteriorly between glutæus medius and minimus, also dividing into two: (i.) *superior branch* follows anterior gluteal line, along upper border of glut. minimus, to deep surface of tensor fasciæ latæ; (ii.) *inferior branch* runs forwards and downwards across glut. minimus, under glutæus med., towards trochanter major.

Branches of sup. gluteal *anastomose* with inf. gluteal, int. pudendal, medial and lateral circumflex, deep circumflex iliac, lateral sacral.

Obliterated umbilical artery (obliterated hypogastric) arises near end of ant. division; runs anteriorly and downwards along side wall of pelvis, above obturator nerve, in contact with full bladder, some distance from it when empty; and proceeds upwards from bladder to umbilicus. Covered by peritoneum; crossed by ureter and ductus deferens (lig. teres in female). Gives off sup. vesical arteries, and beyond that point it has no lumen and is called *lateral umbilical lig.*

Superior vesical, 2 or 3 branches, run medially to bladder, supply its upper part and give branches to urachus, ureter and ductus deferens.

Inferior vesical artery runs medially upon levator ani, crossed by ureter and ductus deferens, to base of bladder, supplying it and vesiculae seminales, prostate, ureter; and gives off the *arteria deferentialis*, which accompanies ductus deferens to testis, anastomosing with both ext. and int. spermatics.

Middle hæmorrhoidal artery arises often in common with inf. vesical. Runs medially upon levator ani to supply rectum, seminal vesicles, prostate and ductus deferens.

Vaginal artery corresponds to inf. vesical in male. Consists of 1 or 2 branches which run down and medially upon levator ani to vagina, to supply it, and bladder and rectum.

Uterine artery may arise in common with vaginal or middle hæmorrhoidal. Runs medially and forwards upon levator ani to base of broad ligament; then medially between its two layers, above ureter and lateral fornix of vagina. Supplies uterus, uterine tube, ovary, vagina, and lig. teres.

Obturator artery runs downwards and forwards along side wall of pelvis; leaves pelvis through upper part of obturate foramen and divides into anterior and posterior rami, which diverge and form a circle upon the circumference of obturator membrane, under cover of obturator externus.

Relations.—Nerve above, vein below; *lateral*: bone, obturator int., fascia; *medial*: peritoneum, ureter, ductus deferens; and in female, ureter, broad ligament, lig. teres uteri. Ovary is separated from it by peritoneum.

Branches: (a) *muscular*, (b) *vesical*; (c) *pubi branch* ascends on pelvic surface of pubis; anast. with its fellow and with pubic branch of inf. epigastric. This may enlarge to form **abnormal obturator**, replacing normal obturator. (d) *Acetabular branch* runs into hip joint through acetabular notch, and is continued along lig. teres femoris to head of femur.

Internal pudendal artery runs downwards and backwards, anterior to sacral plexus and piriformis; pierces deep fascia, leaves pelvis and enters buttock between piriformis and tip of spine of ischium. In buttock, it lies on tip of ischial spine, under gluteus maximus. Leaves buttock and enters perineum through lesser sciatic foramen. Runs anteriorly in Alcock's canal, in lateral wall of ischio-rectal fossa, $1\frac{1}{2}$ inches from lower surface of tuber ischiadicum, with dorsal nerve of penis above it and perineal n. below it; pierces base of fasciæ of urogenital diaphragm (triangular ligament), and runs between the fasciæ along margin of pubic arch to within $\frac{1}{2}$ inch of symphysis, where it pierces inferior fascia, and divides into dorsal and deep arteries of penis or clitoris.

Branches: (a) *In pelvis*, to piriformis and sacral nerves. (b) *In buttock*, muscular and anastomosing. (c) *In ischio-rectal fossa*:

(i.) **Inferior hæmorrhoidal** crosses ischio-rectal fossa to supply anal canal, skin, glutæus maximus ; (ii.) **perineal artery** pierces base of inferior fascia of urogenital diaphragm (superficial layer of triangular ligament), runs anteriorly under cover of superficial fascia, and ends as **posterior scrotal** in male and **posterior labial** in female ; (iii.) **transverse perineal** often arises from perineal, runs medially along superficial transverse perineal muscle to meet its fellow. (*d*) *In urethral triangle* : (i.) **Arteria bulbi urethræ** pierces inferior fascia of diaphragm and enters bulb of penis, or bulb of vestibule in female ; (ii.) **a. profunda penis vel clitoridis** enters crus penis vel clitoridis at once ; (iii.) **a. dorsalis penis vel clitoridis** passes anteriorly between layers of suspensory ligament on to dorsum of penis or clitoris, where it lies medial to dorsal nerve, and is separated from its fellow by deep dorsal vein of penis.

Inferior gluteal artery (sciatic) runs downwards and posteriorly, pierces fascia in front of piriformis, and, passing between 1st and 2nd, or 2nd and 3rd sacral nerves, leaves pelvis through lower part of greater sciatic foramen ; appears in buttock between piriformis and gemellus superior, medial to sciatic nerve, with which it descends, under cover of glutæus maximus, to back of thigh.

Branches : (*a*) *Muscular* ; (*b*) *cutaneous* ; (*c*) **coccygeal** threads its way through lig. sacro-tuberosum to gain dorsum of coccyx ; (*d*) **Art. comitans n. ischiadici** runs distally on surface or in substance of sciatic n. Inferior gluteal *anastomoses* with lateral sacral, pudendal, superior gluteal, circumflexes, perforating.

External iliac artery arises at level of lumbo-sacral joint, opposite sacro-iliac joint, as branch of bifurcation of common iliac ; runs downwards and laterally in relation to psoas major for $3\frac{1}{2}$ inches, and ends by becoming femoral behind inguinal ligament (Poupart), midway between ant. sup. iliac spine and symphysis pubis. Its vein is posterior to it above, but medial to it below.

Branches : inferior epigastric, deep circumflex iliac.

Relations.—*Anterior* : peritoneum separates it from pelvic colon on left side, ileum and vermiform (often) on right side. Upper part crossed by ureter, and in female by ovarian vessels. Lower end crossed by deep circumflex iliac vein, ductus deferens or ligamentum testes ; and int. spermatic vessels, ext. spermatic n. (genital of genito-crural) and a lymph gland lie on it. *Posterior* : its vein above, psoas and a lymph gland below. *Lateral* : genito-femoral n., spermatic vessels ; psoas above, and a lymph gland at lower end. *Medial* : its

vein below ; pelvic colon or ileum, peritoneum, ureter, ovarian vessels, ductus deferens or lig. teres are medial as well as anterior.

Inferior epigastric artery arises just above inguinal lig., runs upwards and medially, on medial side of abdominal inguinal ring ; pierces transversalis fascia, passes over linea semicircularis into sheath of rectus, where it anast. with other arteries. **Branches** : muscular, cutaneous, pubic, external spermatic.

External spermatic artery or **art. lig. teretis uteri** (Cremasteric) accompanies the spermatic cord (or lig. teres), supplying coverings and anastomosing with ext. pudendal, scrotal (or labial) and int. spermatic. **Pubic branch** descends to pelvic surface of pubis to anast. with pubic branch of obturator. Obturator art. may be replaced by an enlargement of this anastomosis, called **abnormal obturator**, which descends from epigastric, in relation to femoral ring, to obturate foramen.

Deep circumflex iliac artery arises from ext. iliac just above inguinal ligament ; runs laterally along inguinal lig. ; pierces transversalis fascia at ant. sup. iliac spine, pierces transversus abd. a little beyond that, runs backwards between transversus and obliquus int. ; sends an **ascending branch** upwards between them, and ends by anastomosing with ilio-lumbar.

Femoral artery (see also p. 168) begins as continuation of ext. iliac, posterior to inguinal ligament, midway between ant. sup. iliac spine and symphysis pubis ; runs distally through femoral trigone (Scarpa) and adductor canal (Hunter), and ends at junction of middle and distal thirds of thigh by passing through hiatus tendineus of adductor magnus and becoming popliteal. Position indicated, thigh being slightly flexed, abducted and laterally rotated, by proximal $\frac{2}{3}$ of line drawn from point of origin to adductor tubercle.

Branches.—Superficial circumflex iliac, superficial epigastric, superficial and deep external pudendal, profunda femoris, art. genu suprema, unnamed muscular.

Relations. In **femoral trigone** : psoas, pectineus, adductor longus are posterior to it. Vein, on medial side proximally, is posterior to it distally. Profunda vessels lie between it and pectineus. Femoral n. is lateral and separated by small piece of psoas. In **adductor canal** : femoral vein is posterior proximally, posterior and lateral distally. Saphenous n. is anterior. N. to vastus medialis is lateral.

Superficial circumflex iliac artery runs laterally, below inguinal lig., towards ant. sup. iliac spine. **Superficial epigastric artery** runs upwards over inguinal ligament to ant. abdominal wall. **Superficial ext. pudendal artery** runs medially, in front of spermatic cord, to scrotum and penis. **Deep ext. pudendal artery** runs medially, posterior to spermatic cord, to reach scrotum and penis. These four arise near proximal end of femoral artery.

Art. genu suprema (anastomotic) arises from femoral near distal end, and at once divides into two, one branch accompanying saphenous nerve, as far as medial side of knee, the other passing to knee through vastus medialis.

A. profunda femoris (see also p. 169) arises about 1½ inches distal to inguinal lig. from lateral side of femoral; curves posteriorly and medially behind femoral, passes posterior to adductor longus, close to femur; ends as *fourth perforating art.* It gives off lateral and medial circumflex, near its origin; unnamed muscular branches, and four *perforating* branches, which wind round posterior aspect of femur and end in vastus lateralis, the *second* giving the *nutrient* branch to the femur.

Lateral femoral circumflex artery runs laterally upon iliacus among branches of femoral nerve, and divides into three. **Ascending branch** runs proximally under tensor fasciæ latæ. **Descending branch** runs distally along ant. border of vastus lateralis. **Transverse branch** sinks into substance of v. lateralis.

Medial femoral circumflex artery passes posteriorly between adjacent borders of psoas and pectineus, and between obturator ext. and adductor brevis; and, having given off *muscular branches* and an **acetabular branch**, which enters acetabular notch and runs along lig. teres to femur, it ends by dividing into deep and superficial branches. **Ramus profundus** accompanies tendon of obturator externus to trochanteric fossa. **Ramus superficialis** passes backwards between quadratus femoris and adductor magnus.

Popliteal artery (see also p. 178) begins as continuation of femoral at opening in adductor magnus; runs distally and laterally in popliteal fossa to interval between femoral condyles, and then vertically to end at distal border of popliteus by dividing into ant. and post. tibial. Floor of the fossa is anterior to it; popliteal vein, postero-lateral at its proximal end, crosses its posterior aspect to lie on medial side at distal end. Tibial nerve (int. popliteal) is lateral to both artery and vein at proximal end, and crosses them posteriorly to lie on medial side.

Branches.—Muscular, cutaneous, and five genicular articular branches:—Art. genu media (middle genicular, O.T. azygos); art. genu superior lateralis and medialis (sup. genicular); art. genu inferior lateralis and medialis (inf. genicular). They have a great share in anastomosis around knee-joint. Middle genicular pierces post. part of capsule; superior pair pass under cover of respective proximal boundaries of popliteal fossa, proximal to femoral condyles; inferior pair under distal boundaries, the medial artery reaching more distal level than the lateral.

Crucial anastomosis on back of thigh is formed *proximodistally* by gluteal, muscular and perforating of profunda, proximal muscular of popliteal; and *from the sides* by branches of medial and lateral circumflex.

Posterior tibial artery begins as branch of popliteal at distal border of popliteus, opposite distal part of tuberosity of tibia; runs distally and medially to end at distal border of lig. laciniatum (int. annular), midway between tip of malleolus and prominence of heel, by dividing into medial and lateral plantar. **Relations:** Venæ comites. *Anterior:* tibialis posterior, flexor digitorum longus, distal end of tibia. *Posterior:* proximal half—gastrocnemius and soleus; distal half—fasciæ and lig. laciniatum. Tibial nerve crosses it, medio-laterally, $1\frac{1}{2}$ inches distal to origin. *At ankle:* flex. dig. longus, and tibialis post. are medial to it; tibial nerve and flex. hallucis longus are lateral.

Branches.—(1) Muscular; (2) cutaneous; (3) *peroneal*; (4) *nutrient* to tibia; (5) *communicating branch* runs transversely in front of flex. hall., 1 inch from distal end of tibia, to join similar branch of peroneal; (6) *posterior medial malleolar*, often absent, ramifies over medial malleolus; (7) *medial calcanean branches* pierce lig. laciniatum to gain lower surface of heel; (8) terminal branches.

Peroneal artery arises about $1\frac{1}{2}$ in. from origin of post. tibial; runs distally and laterally, accompanied by venæ comites, with tibialis posterior in front of it, soleus and flex. hallucis longus behind it; crosses behind tibio-fibular syndesmosis and ends, distal to lateral malleolus, on calcaneus, by dividing into lateral calcanean branches.

Branches.—(a) Muscular; (b) *nutrient* to fibula; (c) *communicating branch* joins similar branch of tibial; (d) *perforating branch* pierces interosseous membrane, runs distally on ant. aspect of lateral malleolus, and anastomoses with other arteries on dorsum of foot.

Medial plantar artery (see also p. 185) arises at distal border of lig. laciniatum (int. annular); runs under cover of abductor hallucis, then between it and flexor dig. brevis to base of hallux, and ends by joining plantar digital art. to medial side of hallux.

Branches.—(1) Muscular; (2) cutaneous; (3) three branches accompany digital branches of medial plantar n.

Lateral plantar artery (see also p. 185), larger than medial, begins at distal border of lig. laciniatum; runs distally and laterally under cover of abductor hallucis and flex. digitorum brevis, accompanied by lateral plantar nerve; and at base of 5th metatarsal it turns medially across sole to base of 1st metatarsal as plantar arch.

Branches.—Muscular, cutaneous; *medial calcanean* pierce abd. hallucis to reach plantar surface of heel.

Plantar arch (see also p. 185), formed by lateral plantar, completed medially by junction with dorsalis pedis at *proximal end* of 1st intermetatarsal space. Lies on bases of middle three metatarsals, and is accompanied by deep branch of lateral plantar nerve.

Branches.—(1) *Post. perforating* pass through lateral three intermetatarsal spaces to join dorsal metatarsal arteries; (2) **three plantar metatarsal arteries** run to clefts between lateral four toes; each sends an *anterior perforating* branch to join a dorsal metatarsal, and divides into *two plantar digitals* to supply adjacent sides of toes; (3) *plantar digital* artery to lateral side of little toe.

Anterior tibial artery arises at distal border of popliteus, as a terminal branch of popliteal; runs distally and forwards, embraced by bifid proximal end of tibialis posterior; pierces proximal part of interosseous membrane, and proceeds upon interosseous membrane and lower end of tibia to ant. aspect of ankle-joint, midway between malleoli, where it ends as dorsalis pedis. **Relations:** accompanied by v. comites. In anterior compartment of leg, the deep peroneal n. (ant. tibial) approaches it from lateral side, lies on ant. surface in middle $\frac{1}{3}$; lies on lateral side in distal $\frac{1}{3}$. Proximal part is deeply placed between tibialis anterior medially, ext. dig. longus and ext. hall. longus laterally. Distal part, more superficial, is overlapped by ext. hallucis, and then crossed by its tendon.

Branches.—(1) **Posterior tibial recurrent** arises on back of leg, runs proximally, under cover of popliteus, to back of knee-joint;

(2) **superior fibular** arises at back of leg; turns round neck of fibula, under cover of soleus; (3) **anterior tibial recurrent** runs proximally, through tibialis anterior, to the anterior aspect of knee; (4) *muscular and cutaneous*; (5) **lateral anterior malleolar** runs under cover of tendons of ext. dig. longus and peronæus tertius to surface of lateral malleolus; (6) **medial anterior malleolar** runs under tendons of ext. hall. longus and tibialis ant. to surface of medial malleolus.

A. dorsalis pedis (see also p. 189) begins on ant. aspect of ankle, midway between malleoli, as continuation of ant. tibial; runs distally, upon talus, astragalus, navicular and 2nd cuneiform, to *proximal end* of 1st intermetatarsal space; dips down into sole, and ends by joining plantar arch.

Branches. -- (1) *Cutaneous*; (2) **lateral tarsal** and (3) **arcuate** (O.T. **metatarsal**) **arteries** run laterally beneath ext. dig. brevis, and the arcuate sends *three dorsal metatarsal branches* to clefts between the four smaller toes; (4) **first dorsal metatarsal** arises at proximal end of metatarsal space, and proceeds to first cleft; (5) **first plantar metatarsal** arises in sole, at the point where dorsalis pedis joins plantar arch; runs to 1st cleft, and divides into *plantar digitals* for both sides of great toe and medial side of second.

VEINS

Pulmonary veins, begin in capillaries of lungs and convey oxygenated blood to left atrium.

Portal system of veins, begins in capillaries of abdominal part of alimentary canal, and of spleen and pancreas; principal trunk is **portal vein** which breaks up into capillaries in liver, from which the blood is conveyed to inf. vena cava by hepatic veins.

Systemic veins arise in capillaries of all other parts of body and contain impure blood. Principal trunks—**coronary sinus**, **superior and inferior venæ cavæ**—convey systemic and portal blood to right atrium.

VENÆ PULMONALES

Pulmonary Veins.—Two on each side, pierce fibrous layer of pericardium; receive covering on anterior, upper, and lower surfaces from serous layer; enter upper and posterior part of left atrium, near right and left borders respectively.

Relations.—In root of lung, upper vein is below and anterior to artery; lower vein is below bronchus. On right side, upper vein passes posterior to superior v. cava; lower vein is posterior to right atrium. On left side both are anterior to descending aorta, upper being separated from it by bronchus.

SYSTEMIC VEINS

Deep veins accompany arteries (*venæ comites*). Large arteries have only one accompanying vein; medium and small arteries have usually two. **Superficial veins** lie in superficial fascia, anastomose with one another, communicate with deep veins and, after piercing deep fascia, end in deep veins. They may or may not accompany superficial arteries. **Visceral veins** accompany visceral arteries, usually one to each. Excepting those which form portal system, they end in deep veins.

VEINS OF THE HEART

Coronary sinus receives most of veins of heart. Lies at lower border of base of heart in groove between left atrium and ventricle, covered superficially by some fibres of atrium and by serous pericardium; in relation with circumflex branch of left coronary art. Ends in lower part of right atrium, between auriculo-ventricular and inf. caval openings, and is guarded by an incompetent unicuspid valve.

Tributaries.—(1) **Great cardiac vein**, begins at apex of heart, accompanies firstly the ant. branch, and next the circumflex branch of left coronary, and ends in left end of sinus. (2) **Small cardiac vein**, begins at inf. margin of right ventricle and runs to the left in atrio-ventricular groove to end in sinus near right end. (3) **Middle cardiac vein**, begins at apex, runs posteriorly in inf. inter-ventricular sulcus to terminate in sinus near right end. (4) **V. obliqua atrii sinistri** (Marshall) (**oblique cardiac vein**) descends obliquely over post. surface of atrium, from in front of left pulmonary v., ends in middle of sinus; it represents part of embryonic left superior v. cava. (5) *Small unnamed tributaries* from surface of heart.

Veins of Heart not ending in Coronary Sinus.—(1) *Anterior cardiac veins*, from sterno-costal surface of right ventricle, open directly into right atrium. (2) *Venæ cordis minimæ*, from substance of heart, open directly into cavities, chiefly into atria.

VENA CAVA SUPERIOR AND ITS TRIBUTARIES

Superior vena cava, 3 inches long, begins posterior to lower border of 1st right costal cartilage by union of 2 innominate; pierces pericardium opposite 2nd right cartilage; ends in upper and posterior part of right atrium, behind 3rd right cartilage. **Tributaries**: two innominate veins, vena azygos; small mediastinal and pericardial veins.

Relations (see also p. 427).—Right pleura and lung are on right side, and overlap it in front and behind. Ascending aorta on left side, and slightly anterior below. Innominate art. on left side above. Phrenic nerve on right side. Root of lung is posterior. Lower part, within fibrous pericardium, covered on ant. aspect and sides by serous. Vena azygos enters posteriorly just before v. cava pierces pericardium.

Vena Azygos.—Arises either from inf. vena cava at level of renal v., or from *right ascending lumbar vein* (p. 308). Enters thorax through aortic hiatus, and runs upwards in posterior mediastinum, on the right side of aorta. At level of 5th vertebra it arches forwards over root of right lung and ends in sup. v. cava.

Relations.—**In abdomen**: Lies on upper l. vertebrae, posterior to right crus, to the right of cisterna chyli. **In thorax**: Lies on lower 8 vertebrae and right aortic intercostals. Aorta and thoracic duct on its left side. Pleura and lung on its right side. Overlapped by œsophagus anteriorly. As it arches forwards, root of lung is inferior; pleura and lung on right side and above; œsophagus, trachea, and vagus on left side. (See also p. 433.)

Tributaries—(1) Upper right lumbar; (2) right subcostal; (3) right posterior intercostals from lower 8 spaces; (4) right superior intercostal from 2nd and 3rd spaces; (5) right bronchial; (6) œsophageal, pericardial and mediastinal; (7) hemiazygos; (8) accessory hemiazygos.

V. Hemiazygos (v. az. minor inf.) arises from left ascending lumbar; pierces left crus, ascends on lower 11l. vertebrae and intercostal arteries, on left side of aorta. At level of 9th or 8th, it turns to the right, posterior to aorta and thoracic duct, and ends in v. azygos. It receives blood from upper lumbar veins, left subcostal, 3 or 4 lower left intercostals.

V. Hemiazygos accessoria (v. az. minor sup.) is formed by 4th to 7th or 8th left intercostals. Lies on left side of 5th to 8th vertebrae; turns to the right at 8th, posterior to aorta and thoracic duct, and ends

in v. azygos. Communicates with left sup. intercostal. Receives left bronchial.

(Anterior intercostal veins end in musculo-phrenic and internal mammary.)

Venæ anonymæ, dextra et sinistra (Innominate veins) (see also pp. 214, 217), begin in the neck, behind sternal ends of respective clavicles, on anterior aspect of pleural dome, by the union of int. jugular and subclavian. **Right vein**, 1 inch long, descends almost vertically on right side of innominate artery. **Left**, 3 inches long, passes obliquely to the right and downwards, between upper part of manubrium and the three branches of aortic arch. They end by uniting behind lower border of 1st right costal cartilage to form sup. v. cava.

Tributaries.—A. In neck: 1. **Right lymphatic duct** on right side, **thoracic duct** on left side.

2. **Vertebral veins**: arise from intra-spinal plexuses; leave upper end of vertebral canal, cross post. arch of atlas, and are joined by veins from sub-occipital plexus; descend foramina transversaria as plexus around vertebral artery; emerge from 6th for. transversarium as single vein which descends anterior to vertebral and subclavian arteries to end in innominate. *Receives* (i.) tributaries from deep muscles, bones, etc., of head and neck; (ii.) offsets from spinal plexuses; (iii.) anterior vertebral, accompanying asc. cervical art.; (iv.) deep cervical vein, accompanying art. profunda cervicis.

3. **V. intercostalis suprema**, from posterior part of 1st space, arches over apex of pleura to end in vertebral or innominate.

B. In thorax: 4. **Internal mammary veins**—venæ comites of int. mammary art. unite to form single vein before entering innominate at thoracic inlet. Possess numerous valves. *Receive* (i.) anterior intercostal veins from upper six spaces; (ii.) perforating; (iii.) muscular; (iv.) mediastinal, pericardial and thymic veins; (v.) venæ comites of sup. epigastric and musculo-phrenic art.

5. **Inf. thyreoid veins** descend on ant. surface of trachea in neck and end in one or other innominate in thorax.

6. **Left superior intercostal**, from 2nd and 3rd spaces, crosses left or anterior surface of aortic arch and joins *left* innominate vein.

VEINS OF HEAD AND NECK

Internal jugular vein begins in jugular foramen, opposite lower border of ext. acoustic meatus, as continuation of transverse (lateral) sinus. Ends behind sternal end of

clavicle by joining subclavian to form innominate. At or near its termination there is a valve. Both veins trend to right in descent, so that left vein is almost in front of common carotid at lower end, while right vein is a little way lateral to it. Right vein is usually the larger. Its position may be indicated by a line drawn from lower border of ext. meatus to medial end of clavicle. Above clavicle it lies opposite depression between sternal and clavicular heads of sterno-mastoid. (See also pp. 213, 217, 220.)

Relations.—Enclosed in carotid sheath. Dilated at origin to form **Bulb**, which lies in jugular foramen. Upper part of vein lies behind int. carotid and last 4 cerebral nerves.

Superficial: (1) sterno-mastoid; (2) lymph glands; (3) parotid gland, facial n., styloid process, stylo-pharyngeus, stylo-hyoid; (4) post. belly of digastric, post. auricular vessels, occipital art., accessory n.; (5) branches to sterno-mastoid from superior thyreoid and occipital arteries; (6) descendens cervicalis n.; (7) omo-hyoid; (8) ant. jugular vein; (9) sterno-hyoid, sterno-thyreoid. **Medial:** at base of skull last 4 cerebral ns.; below that, vagus on post. plane, and int. carotid above, common carotid below. **Posterior:** (1) rectus lateralis, accessory n. sometimes; (2) cervical transverse processes; (3) ascending cervical art.; (4) longus capitis (rect. cap. ant. major), levator scapulæ, scalenus medius and anterior; (5) cervical plexus, phrenic n.; (6) vertebral vein; (7) thyreo-cervical trunk (thyreoid axis) and its branches near origins; (8) subclavian art., apex of pleura and lung; and, on left side, (9) thoracic duct.

Tributaries (see also p. 220).—(1) Inf. petrosal sinus at base of skull; (2) pharyngeal veins from plexus on wall of pharynx; (3) common facial vein; (4) lingual vein; (5) superior and middle thyreoid veins.

Subclavian vein begins at outer border of 1st rib as continuation of axillary. Runs medially on 1st rib, posterior to subclavius and clavicle, anterior to and at a lower level than subclavian artery, from which it is separated by scalenus anterior. Ends at medial border of scalenus ant., behind clavicle near its sternal end, by joining int. jugular to form innominate. **Tributary:** ext. jugular. It has a valve on distal side of entrance of ext. jugular.

Veins of Scalp (see also p. 231).—**Frontal** and **supra-orbital** unite at medial angle of eye to form **angular**. **Superficial temporal** unites with middle temporal to form posterior facial vein.

Posterior auricular joins ext. jugular. **Occipital** receives parietal and mastoid emissary veins, passes to plexus in sub-occipital space, which is drained by vertebral and deep cervical.

Vv. diploicæ frontalis, temporales ant. et post. and occipitalis begin in anastomosing spaces in spongy tissue (diploë) of flat skull bones. End in supra-orbital vein, spheno-parietal sinus, transverse (lateral) sinus.

Meningeal veins begin in plexuses in dura mater, and accompany meningeal arteries.

Veins of Orbit combine to form **superior and inferior ophthalmic veins**, which pass through sup. orbital fissure, to end in cavernous sinus. They communicate with angular, and, through inferior orbital fissure, with pterygoid plexus.

Veins of Nose combine to form **spheno-palatine**, which passes through for. spheno-pal. to pterygoid plexus. They communicate with ophthalmic and nasal tributaries of ant. facial.

Pterygoid plexus surrounds pterygoid muscles and receives tributaries accompanying branches of int. maxillary art. Communicates with cavernous sinus through for. ovale, with ophth. veins through inf. orbital fissure, with pharyngeal plexus, with ant. facial vein by *deep facial vein*, which lies between buccinator and masseter. **Internal maxillary vein** arises out of it posteriorly, passes backwards between neck of mandible and spheno-mandibular lig., enters parotid to join post. facial.

Posterior facial vein is formed by union of superficial temporal and middle temporal veins above zygoma; descends in front of ear. Lies superficial to ext. carotid and deep to divisions of facial n. in parotid. Gives branch to form ext. jugular; emerges from lower part of parotid; joins ant. facial, below angle of mandible, to form common facial.

Anterior facial vein begins as angular vein at medial angle of eye, runs downwards and posteriorly, a little way behind ext. maxillary art. (facial), receiving tributaries corresponding to its branches. Descends superficial to lower part of masseter and submaxillary gland; joins posterior facial to form common facial. Communicates with pterygoid plexus by deep facial vein.

Common facial vein passes posteriorly under cover of sterno-mastoid across ext. and int. carotids and joins int. jugular.

External jugular vein begins below lobe of ear, by union of post. auricular with branch from post. facial. Descends almost vertically across sterno-mastoid, pierces deep fascia at its post. border, $\frac{1}{2}$ inch above clavicle; crosses

3rd part of subclavian art., ends in subclavian vein. Has valve at termination and another higher up. See also p. 206.

Anterior jugular vein begins in small veins below chin; descends near median plane, pierces the superficial of the two laminae of deep fascia above manubrium; anastomoses with its fellow by means of a transverse branch; passes laterally behind sterno-mastoid, to end in ext. jugular vein.

Veins of Brain.—Very thin-walled.

Chorioid vein arises in chorioid plexus of inf. horn of ventricle, runs along chorioid plexus of body of ventricle to join terminal vein at interventricular foramen (Monro) to form internal cerebral vein.

Vena terminalis (vein of corpus striatum) lies in groove between thalamus and caudate nucleus; receives blood from them and lentiform nucleus; joins chorioid vein.

Internal cerebral vein runs backwards between layers of tela chorioidea of 3rd ventricle (velum interpositum); joins its fellow below splenium to form **v. cerebri magna (Galenii)**, which emerges from tela chorioidea, joins inferior sagittal (longitudinal) sinus to form straight sinus. **Inferior striate vein** descends from caudate and lentiform nuclei through ant. perforated substance to join basilar vein.

Superior cerebral veins, 12 or more, lie in pia and sub-arachnoid space of convex surface of cerebrum, drain convex and medial surfaces; enter sup. sagittal sinus. **Inferior cerebral veins** lie on convex and inferior surfaces, end in transverse, sup. petrosal and cavernous sinus. One of latter, called *superficial middle cerebral*, lies in fissura lateralis (Sylvius) and is united by *great anastomatic vein* with superior sagittal sinus, and by *post. anastomatic vein* with transverse (lateral) sinus. **Ant. cerebral vein** accompanies ant. cerebral art. and ends in basilar vein. **Deep middle cerebral vein**, in fissura lateralis, ends in basilar. **Basilar vein** formed at ant. perforated substance by union of ant. cerebral, deep middle cerebral and inferior striate, passes round cerebral peduncle and ends in vena cerebri magna (Galenii).

Veins of mesencephalon end in vena cerebri magna.

Superior cerebellar veins end in v. cerebri magna and transverse or sup. petrosal sinus. **Inferior cerebellar veins** end in straight, transverse, inf. petrosal and occipital sinuses. **Veins of pons** end in basilar vein and sup. petrosal sinus (or join cerebellar). **Veins of medulla oblongata** communicate with veins of spinal medulla and pons, and join inf. petrosal and occipital sinus and basilar plexus.

BLOOD SINUSES OF CRANIUM

Lie between layers of dura mater.

Unpaired sinuses: (1) Superior sagittal sinus (sup. longi-

tudinal) begins by small vein ascending from nose through foramen cæcum. Extends upwards, backwards, and finally downwards, in attached margin of falx cerebri, grooving frontal, parietals, and upper part of occipital. Ends at side of occipital protuberance by turning to the right (sometimes left) and becoming transverse sinus. *Receives* sup. cerebral veins, the posterior members of which enter it in direction contrary to blood flow in it. *Communicates* with occipital veins through parietal foramen, and with spaces in dura into which arachnoideal granulations (Pacchionian bodies) project. *Confluens sinuum* (Torcular Herophili) is a dilatation at its termination with which other sinuses communicate.

(2) **Sinus rectus (straight sinus)** formed by v. cerebri magna (Galen) and inf. sagittal sinus. Runs postero-inferiorly in attachment of falx cerebri to tentorium, dilates at int. occip. protuberance and turns usually to the left to form left transverse sinus. *Receives* some sup. cerebellar veins, and veins from falx; *communicates* with confluens sinuum.

(3) **Inferior sagittal sinus** (inf. longitudinal) lies in post. $\frac{2}{3}$ of lower edge of falx cerebri; ends at anterior edge of tentorium by joining v. cerebri magna to form straight sinus. *Tributaries* from falx and middle $\frac{1}{3}$ of medial surface of hemisphere.

(4) **Anterior and posterior intercavernous sinuses**, in attached margins of diaphragma sellæ, in front of and behind fossa hypophyseos (pituitary fossa), connect cavernous sinuses, and with them form **circular sinus**.

(5) **Plexus basilaris** lies on cerebral surface of basilar part of occipital bone. It communicates with cavernous and inf. petrosal sinuses and with spinal veins.

Paired Sinuses.—**Transverse sinus** (lateral sinus) begins at int. occip. protuberance; runs laterally and anteriorly in lateral border of tentorium, grooving occipital and mastoid angle of parietal. Leaves tentorium to lie between layers of dura, and runs downwards and medially, grooving medial surface of mastoid temporal; then forwards and medially, grooving jugular process of occipital; turns downwards through jugular foramen to end as int. jugular vein. *Position* indicated on surface by line drawn from ext. occip. protuberance, slightly convex upwards, to upper part of mastoid temporal (about $1\frac{1}{2}$ inch above and behind centre of meatus), then downwards and forwards over mastoid to level

of lower border of meatus, but behind it. *Receives* sup. petrosal sinus, some sup. and inf. cerebellar and inf. cerebral veins, and post. diploic vein. *Communicates* with veins outside, through mastoid foramen and condyloid canal (post. condyloid foramen).

Sinus cavernosus lies at side of body of sphenoid. Cavity is traversed by fibrous bands. In lateral wall are imbedded int. carotid art., with sympathetic plexus; oculo-motor, trochlear, abducent and ophthalmic nerves; and maxillary n. runs forwards along lower border. *Receives* ophthalmic veins and spheno-parietal sinus in front; inferior cerebral veins above. *Communicates* medially with its fellow by intercavernous sinuses and basilar plexus; with pterygoid plexuses inferiorly through foramen ovale or for. Vesalii. Sup. and inf. petrosal sinuses leave its posterior end.

Spheno-parietal sinus lies on lower surface of small wing of sphenoid; communicates with meningeal veins; ends in cavernous sinus.

Superior petrosal sinus begins at post. end of cavernous sinus, at apex of petrous temporal; lies in attachment of tentorium to upper border of petrous, ends in transverse sinus. *Receives* inf. cerebral, sup. cerebellar, tympanic, and diploic veins.

Inferior petrosal sinus leaves post. end of cavernous, runs posteriorly, downwards and laterally in groove on junction of petrous temporal and basi-occiput; passes through jugular foramen and ends in jugular vein. Connected with fellow by basilar plexus. *Receives* inf. cerebellar veins, and veins from internal ear.

Occipital sinus extends from lower end of transverse sinus, round for. magnum and up falx cerebelli to upper end of trans. sinus. *Communicates* with spinal veins and receives some inf. cerebellar veins.

SPINAL VEINS

Anterior external vertebral plexus, on anterior surfaces of bodies of vertebræ, and **posterior external vertebral plexus**, around vertebral arch and processes, send efferents to join vertebral, intercostal, lumbar, and lateral sacral veins. **Anterior longitudinal vertebral sinuses** lie at sides of post. longitudinal lig.; extend from for. magnum to coccyx; connected by cross branches, each of which receives **vena basalis vertebræ** from substance of body of vertebra. Communicate with post. longitud. sinuses, occipital sinus and basilar plexus, and, by means of *intervertebral veins*, with vertebral, intercostal, lumbar and lateral sacral veins. **Posterior longitudinal vertebral sinuses** lie between dura and laminae; anastomose with

one another, with other veins in neighbourhood, and occipital sinus and basilar plexus.

Veins of spinal medulla (cord) form plexuses on surface, from which (1) **radicular** vessels pass along nerve roots to end in offsets of longitudinal vertebral plexuses; (2) **ant. and post. median veins** pass up to end in similar veins of medulla oblongata; (3) **antero-lateral and postero-lateral veins** run up behind ant. and post. nerve roots and send their blood to median and radicular veins.

VEINS OF SUPERIOR EXTREMITY

Deep veins, except axillary vein, accompany arteries as *venæ comites*, which are provided with valves; and their blood is conveyed ultimately to axillary vein.

Axillary vein begins opposite lower border of *teres major*, as continuation of basilic vein; runs upwards and medially, on medial side of axillary artery, from which it is separated by medial cord of brachial plexus and the ulnar nerve; and ends at outer border of 1st rib by becoming subclavian. It possesses several valves. It is enclosed, with artery and cords of brachial plexus, in a fascial sheath. See also p. 131.

Tributaries.—*Venæ comites* of branches of axillary art.; *v. comites* of brachial art., at lower border of subscapularis; cephalic vein.

Superficial veins anastomose, forming plexuses. Principal channels are: **Dorsal venous arch** lies opposite distal parts of metacarpals on dorsum of hand. **Median vein of forearm** begins at base of thumb, extends to cubital fossa, communicates there by *deep median vein* with deep veins, and divides into median basilic and median cephalic. **Median basilic** runs proximally and medially, in front of *lacertus fibrosus* (bicipital fascia) and brachial artery, behind volar branch of medial cutaneous n. of forearm (int. cutaneous), and joins the basilic vein. **Median cephalic** runs proximally and laterally, in front of lateral cutaneous nerve of forearm (cutaneous of musculo-cutaneous), and joins the cephalic.

Basilic vein begins at ball of little finger, runs along ulnar border of forearm, usually as two trunks, which join with median basilic at the bend of elbow; and the single trunk, so formed, runs proximally in groove along medial border of biceps, pierces deep fascia about middle of arm, extends

along medial side of brachial art. to end at lower border of teres major by becoming axillary. It possesses several valves.

Cephalic vein begins on dorsum of hand, runs along radial border or volar surface of forearm, and having been joined, at bend of elbow, by the median cephalic vein, it runs proximally in groove along lateral side of biceps, pierces deep fascia, to lie between pectoralis major and deltoid. Below clavicle it turns medially under pect. major, pierces costo-coracoid membrane, and ends in axillary vein. It also has several valves.

VENA CAVA INFERIOR AND ITS TRIBUTARIES

Inferior vena cava begins at right side of body of 5th L. vertebra, behind right common iliac art., by union of common iliac veins; ascends upon vertebral column and diaphragm; pierces central tendon of diaphragm, between its right and median segments, opposite 8th TH. vertebra; pierces pericardium, and ends in lower and posterior part of right atrium.

Tributaries.—Hepatic veins, right inferior phrenic, right suprarenal, renals, right spermatic or ovarian, lumbar, common iliacs.

Relations in abdomen.—*Anterior:* (1) liver; (2) foramen epiploicum (Winslow), right, free edge of lesser omentum containing portal vein, bile duct, hepatic art.; (3) superior or 1st part of duodenum, with portal vein, bile duct, gastroduodenal art. intervening; (4) head of pancreas and lower part of bile duct; (5) inferior or 3rd part of duodenum; (6) peritoneum on post. abdominal wall, with right colic and ileo-colic vessels, and int. spermatic or ovarian art. intervening; (7) root of mesentery containing superior mesenteric vessels; (8) right common iliac artery.

Left side: aorta in contact below, but separated by right crus of diaphragm and liver above. *Right side:* ureter, kidney, suprarenal, liver, from below upwards. (It is imbedded, at upper end, in groove on post. aspect of liver, so that liver is on the right and left as well as anterior.)

Posterior: diaphragm above, with right inf. phrenic art., small part of suprarenal gland, cœliac (Semilunar) ganglion, suprarenal and renal arteries intervening; posterior to it at a lower level are bodies of lower lumbar vertebrae, anterior

longitudinal lig., lower two aortic lumbar arteries, sympathetic trunk, psoas major. When empty it may be medial to psoas and symp. trunk, or may merely overlap trunk.

In thorax: owing to slope of diaphragm it presents only posterior and right lateral surfaces, both related to pleura and lung. Phrenic nerve descends between its right surface and pleura. Pleura and lung separate posterior surface from right greater splanchnic nerve, 9th right intercostal vessels and 9th thoracic vertebra.

Right and left hepatic veins issue from post. aspect of liver, and at once enter v. cava. Caudate (Spigelian) lobe often provides a third vein.

Inferior phrenic veins.—Venæ comites of right artery enter upper end of v. cava; those of left artery end usually in left suprarenal.

Suprarenal vein issues from hilum of suprarenal. Enters v. cava at once on right side. On left side it runs down to renal vein.

Right renal vein, 1 inch long, crosses to v. cava, anterior to renal artery, posterior to descending part of duodenum.

Left renal vein, over 2 inches long, also anterior to its artery, crosses left psoas and crus of diaphragm, and aorta, just below origin of sup. mesenteric art. Terminal part of duodenum and head of pancreas are anterior to it. It receives left suprarenal and left spermatic or ovarian veins.

Spermatic Vein.—Veins from testis and epididymis accompany artery in spermatic cord as **pampiniform plexus**, from which two veins arise at abdominal inguinal ring and accompany art. in abdomen. Finally unite to form one vein, which on right side enters v. cava, on left side runs upwards to renal vein.

V. ovarica (Ovarian vein).—Veins of each ovary also form **pampiniform plexus**, from which two veins issue at brim of pelvis, and terminate like spermatics.

Vv. lumbales (Lumbar veins), 4 in number, lie between psoas and bodies of upper 4 l. vertebræ. Those of left side pass posterior to aorta, the upper ones passing posterior to crura of diaphragm also. Lumbar veins are connected by longitudinal anastomosing channel, in front of roots of transverse processes, called **ascending lumbar vein**, which ends in vena azygos on right side, and in v. hemiazygos on left side.

Common iliac vein begins at superior aperture of pelvis minor, behind upper part of hypogastric (int. iliac) art., by union of hypogastric and ext. iliac veins. Ends at right side of body of 5th l. vertebra by joining its fellow to form v. cava inferior. **Right vein** is first posterior, then postero-lateral to its artery; and anterior to obturator n. and ilio-lumbar artery. **Left vein** passes

upwards and to the right, across body of 5th l. vertebra and mid. sacral art., along medial side of left common iliac artery, to end behind right common iliac art. It is crossed by pelvic mesocolon and sup. hæmorrhoidal vessels.

Tributaries.—**Ilio-lumbar vein** emerges at medial side of psoas major and ends in common iliac of its own side. **Middle sacral vein**: venæ comites of middle sacral art. unite to form single vein which opens into *left* common iliac.

External iliac vein begins, as continuation of femoral, posterior to inguinal ligament at medial side of termination of ext. iliac art. Ends opposite lumbo-sacral joint, posterior to upper end of hypogastric art., by joining hypogastric vein to form common iliac.

Relations.—Lies medial to its artery below, posterior to it above. Psoas major is lateral; medial to it are peritoneum, and ductus deferens (or round lig. of uterus) below, and ovarian vessels, ureter and hypogastric art. above. Obturator n. is posterior.

Tributaries.—Inferior epigastric and deep circumflex iliac veins end in it near its origin. It may receive *pubic vein*, which connects it with obturator.

Hypogastric vein (internal iliac) begins at upper part of greater sciatic notch; ascends to superior aperture of pelvis to join ext. iliac. Lies posterior and medial to its artery. Obturator n. is lateral to it. Sacro iliac joint is posterior to it. Medial to it is pelvic colon on left side and ileum on right side.

Tributaries correspond to branches of hypogastric art., except ilio-lumbar and umbilical (obliterated hypogastric). Veins from walls of pelvic viscera lie partly in fascia surrounding them, and partly between fascia and viscera, and form plexuses, from which large veins issue to accompany corresponding arteries. Portal and systemic systems of veins anastomose in walls of rectum, some of blood from rectum is returned by sup. hæmorrhoidal to portal system, and some by middle hæmorrhoidal and by inf. hæmorrhoidal (through int. pudendal) to hypogastric vein. *Superficial dorsal vein of penis* ends by dividing into right and left branches, which join superficial ext. pudendal of respective sides. *Deep dorsal vein* of penis ends, not in int. pudendal, but passes into pelvis between arcuate pubic ligament and fascia of uro-genital diaphragm to join pudendal (prostatic) plexus; and in female, *dorsal vein of clitoris* ends in vesical plexus.

VEINS OF INFERIOR EXTREMITY

Deep Veins.—Two venæ comites accompany all arteries in lower limb, except popliteal, femoral, and profunda femoris. They have numerous valves.

Popliteal vein begins at distal border of popliteus by union of ant. and post. tibial venæ comites. Runs proximally, crossing posterior to popliteal art. from medial to lateral side, separating it from tibial nerve. Ends at hiatus tendineus in adductor magnus by becoming femoral. It possesses 4 valves. **Tributaries** correspond to branches of popliteal artery, with small saphenous vein in addition.

V. profunda femoris lies anterior to its artery, and ends in femoral vein in femoral trigone.

Femoral vein begins at opening in adductor magnus, at junction of middle and distal thirds of thigh, posterior and lateral to artery, as continuation of v. poplitea, and ends, posterior to inguinal ligament, on medial side of artery, by becoming ext. iliac (see also p. 169). Has valve at termination, and another where profunda enters it.

Tributaries.—Profunda vein; venæ comites of art. genu suprema (anastomotic), of lateral and medial circumflex, of deep external pudendal and of unnamed muscular; great saphenous vein.

Superficial Veins anastomose forming plexuses. Chief channels are :—

Dorsal venous arch lies across distal parts of metatarsals.

Great saphenous vein begins at medial side of foot. Extends proximally, anterior to medial malleolus, and along medial border of tibia, and behind medial condyle of femur; inclines laterally and anteriorly to reach fascia cribrosa, which it pierces to enter femoral vein. It has 8-20 valves. It receives numerous unnamed tributaries; and veins accompanying superficial ext. pudendal, epigastric and circumflex iliac arteries enter it before it pierces fascia cribrosa.

Small saphenous vein begins on lateral border of foot. Extends proximally, behind lateral malleolus, and on back of leg to popliteal fossa, where it pierces popliteal fascia and joins popliteal vein. It has 6-12 valves.

PORTAL SYSTEM OF VEINS

Includes veins conveying blood to liver from spleen, pancreas and abdominal part of alimentary canal (except part of blood from anal canal and lower end of rectum). They correspond to arteries supplying these parts. The

larger veins have no valves, but smaller tributaries have. Tributaries of portal system communicate with tributaries of systemic veins at lower end of œsophagus, lower end of rectum, on post. wall of abdomen, and along lig. teres of liver.

Vena portæ (Portal vein) is the chief trunk. It begins behind neck and in front of recurved part of head of pancreas, by union of splenic and superior mesenteric, opposite 1st L. vertebra. Ascends anterior to v. cava inferior, posterior to neck of pancreas and superior part of duodenum; turns forwards at upper border of duodenum to enter lesser omentum, between layers of which it ascends to liver, having bile duct anterior and to the right, hepatic art. anterior and to the left. At right end of porta of liver, posterior to branches of hepatic art. and hepatic ducts, it divides into right and left branches, which enter right and left lobes of liver, break up and end in capillaries common to them and to branches of hepatic artery. Hepatic veins arise from these capillaries and carry blood to v. cava inferior. Left branch of portal vein is connected with umbilicus by ligamentum teres—remnant of foetal left umbilical vein—and with inf. v. cava by fibrous remnant of foetal ductus venosus. While v. portæ is posterior to duodenum the bile duct is anterior to it and gastro-duodenal art. is anterior or on left side.

Tributaries.—Splenic, superior mesenteric, coronary, pyloric, a pancreatico-duodenal and sometimes inferior mesenteric; cystic, from gall-bladder, joins its right branch.

V. lienalis Splenic begins at hilum of spleen; passes towards kidney between layers of lieno-renal ligament; runs to the right across left kidney and aorta, behind pancreas, below splenic and celiac arteries, above left renal vein and origin of sup. mesenteric art. Ends by joining superior mesenteric to form vena portæ, behind neck of pancreas.

V. mesenterica inferior accompanies artery, lying to its left side. Above level of origin of artery it ascends medial to ureter, anterior to psoas, spermatic vessels and renal vein, posterior to duodeno-jejunal flexure, to end behind pancreas in splenic vein, or in origin of v. portæ.

V. mesenterica superior accompanies its artery, lying to its right side.

V. coronaria ventriculi ascends along lesser curvature of stomach, between layers of lesser omentum, anterior to omental bursa (lesser

peritoneal sac), to reach œsophageal end of stomach; turns over upper border of bursa and runs downwards and to the right, on right crus behind bursa, to reach duodenum, and enters v. portæ as it turns forwards at upper border of 1st part of duodenum.

Pyloric or right gastric vein runs to right, along lesser curvature, between layers of lesser omentum, and ends in v. portæ as it enters omentum. **Right gastro-epiploic vein** may end in sup. mesenteric or in portal. A **pancreatico-duodenal vein** accompanies superior artery of that name, and ends in sup. mesenteric; but main pancreatico-duodenal vein accompanies bile duct on back of head of pancreas and ends in portal vein.

LYMPHATIC SYSTEM

Terminal lymph vessels are the thoracic and right lymphatic ducts.

Thoracic Duct, 18 inches long, begins in epigastric region of abdomen, on 1st and 2nd lumbar vertebræ, as a dilatation called **cisterna chyli** (receptaculum); passes through aortic hiatus of diaphragm; ascends in posterior mediastinum behind œsophagus, turns abruptly to the left at 5th thoracic vertebra, and ascends superior mediastinum, applied to left side of œsophagus; enters root of neck and turns laterally, between carotid sheath and vertebral artery; bends downwards, anterior to subclavian artery, and enters commencement of left innominate vein. It has numerous valves.

Relations.—**In abdomen:** cisterna chyli, about 2 inches long, lies on 1st and 2nd lumbar vertebræ and arteries, overlapped by right crus, with aorta to its left, vena azygos to its right. **In posterior mediastinum** the duct is separated from vertebræ by right aortic intercostals, ends of hemiazygos veins, and longitudinal ligament; *anterior to it*, there is the diaphragm below, fatty areolar tissue between aorta and right pleura above that, and œsophagus opposite 5th, 6th, 7th and (sometimes) 8th vertebræ. Descending aorta is to its left, and vena azygos to its right. **In superior mediastinum** it lies on left border of œsophagus, separated by fat from longus colli and vertebræ; anterior and to its left side are the aortic arch, pleura, left subclavian art. **In root of neck** it ascends between œsophagus and pleura, and at level of 7th cervical vertebra arches laterally and then downwards above pleura, *posterior to* contents of carotid sheath, *anterior to* vertebral vessels, branches of thyreo-cervical trunk (thyroid axis) at their origin, phrenic nerve, medial border of scalenus

anterior and 1st part of subclavian art. ; and ends in angle of union of int. jugular and subclavian veins, in front of pleura, behind or just above clavicle. See also pp. 218, 430, 434.

Tributaries. —Receives lymph from all parts (except those drained by right lymphatic duct) by means of small vessels and several larger trunks : (1) **Truncus intestinalis**, from cœliac, mesenteric and pre-aortic glands, carries lymph from stomach, small intestines, spleen, pancreas and part of liver. (2) Two **trunci lumbales**, from lateral and retro-aortic glands, convey lymph from lower limbs walls of abdomen, testes, pelvic viscera, large intestine, kidneys and suprarenals. (3) **Retro-aortic trunk**, from retro aortic glands, conveys lymph from post. abdominal wall. (4) Two **descending trunks** descend through aortic opening from lower intercostal glands, conveying lymph from thoracic wall. All these end in cisterna chyli. At root of neck (5) **truncus subclavius** from left upper limb, and (6) **truncus jugularis** from left side of head and neck, end in the duct or in one of the large veins.

Right Lymphatic Duct. —Exceedingly slender. Begins in thorax at 5th TH. vertebra, ascends to neck on ant. aspect of vertebral column ; turns laterally, having a course corresponding to that of thoracic duct. At medial border of scalenus anterior it is joined by jugular and subclavian trunks, and the common trunk descends to end in commencement of right innominate vein. Its entrance is guarded by a valve. It receives lymph from right upper limb, and side of head and neck and thorax, right lung and pleura, right side of heart and pericardium, right half of diaphragm and upper surface of liver. The portion extending from origin to medial margin of scalenus ant. is also called the *broncho-mediastinal trunk*.

LYMPHOGLANDULÆ

LYMPH GLANDS OF HEAD AND NECK

Occipital, 2 or 3 at superior nuchal line, on trapezius or semispinalis capitis (complexus) ; **posterior auricular**, 2 on insertion of sterno-mastoid into mastoid temporal. These receive lymph by *afferent* vessels from posterior part of scalp and transmit it by *efferent* vessels to superficial and upper deep cervical glands. **Anterior auricular**, on surface of parotid ; *afferents* from cheek, root of nose, eyelids and anterior part of scalp and auricle ; *efferents* to superficial and upper deep cervical glands. **Parotid**, in substance of parotid ; *afferents* from meatus, tympanum, soft palate, posterior part of nasal cavity, deep parts of cheek ; *efferents* to upper deep cervical glands. **Deep facial**, on superficial surface of pterygoideus externus ; *afferents* from orbit, temporal and infra-temporal fossæ,

palate, nasal cavity, meninges; *efferents* to upper deep cervical glands. **Superficial facial**, scattered over face; *efferents* from neighbouring parts; *efferents* to submaxillary and parotid glands.

Lingual, between genio-glossi and on hyo-glossus; *efferents* from tongue and floor of mouth; *efferents* to deep cervical glands. **Superficial cervical**, along external jugular vein; *efferents* from superficial tissues of neck, auricle and parotid region, from anterior and posterior auricular and submaxillary lymph glands; *efferents* to supra-clavicular and upper deep cervical glands. **Submaxillary**, between mandible and submaxillary gland; *efferents* from side of nose, cheek, upper lip, lateral part of lower lip, anterior $\frac{1}{3}$ of border of tongue, gums, sublingual salivary gland, floor of mouth, facial and submental glands; *efferents* to upper deep cervical glands.

Submental, below chin, on mylo-hyoid muscle; *efferents* from median part of lower lip, adjacent gum, floor of mouth, tip of tongue, skin below chin; *efferents* to submaxillary glands and to a gland on int. jugular vein at level of cricoid. **Retro-pharyngeal**, opposite upper 2 cervical vertebræ; *efferents* from nasal cavities and sinuses and pharynx, auditory tube and tympanum, adjacent muscles and bones; *efferents* to upper deep cervical glands. **Anterior jugular** on ant. jugular vein, **pre-laryngeal** on crico-thyroid lig., **pretracheal**, **paratracheal**; *efferents* from adjoining parts; *efferents* to deep cervical glands.

Upper deep cervical, under cover of sterno-mastoid, along both sides of carotid sheath, extending from base of skull to thyroid cartilage; *efferents* from back of neck and scalp, auricle, interior of cranium, palate, nasal cavities and pharynx, tonsils, œsophagus, tongue, larynx, trachea and thyroid gland, and the preceding lymph glands. **Lower deep cervical**, along carotid sheath below thyroid cartilage; *efferents* from glands above; *efferents* join with some *efferents* of upper glands to form jugular trunk, which ends in thoracic or right lymphatic duct, or in innominate vein. **Supra-clavicular glands** on roots of brachial plexus and around end of ext. jugular vein; *efferents* from back of neck and scalp, pectoral region, axillary glands; *efferents* to jugular trunk.

LYMPH GLANDS OF SUPERIOR EXTREMITY

Superficial cubital, on anterior aspect of elbow, and proximal to medial epicondyle; *efferents* from volar aspect of forearm and medial part of palm, ulnar side of forearm and palm and medial 2 or 3 digits; *efferents* to brachial or axillary glands. **Deep cubital**, at termination of brachial artery; *efferents* from deep parts of forearm; *efferents* to brachial or axillary glands. **Brachial**, irregular, along brachial art.; *efferents* from forearm, deep and superficial cubital glands, and adjacent parts; *efferents* to axillary glands.

Axillary :—(1) **Lateral**, along axillary vessels and on floor of axilla; *afferents* from whole upper limb, from cubital, pectoral, subscapular glands; *efferents* to subclavian trunk and supra-clavicular glands. See also pp. 135, 136. (2) **Pectoral**, in angle between pectoral muscles and serratus anterior; *afferents* from antero-lateral walls of body above umbilicus, mammary gland; *efferents* to lateral glands. (3) **Subscapular**, along lower border of subscapularis; *afferents* from postero-lateral walls of body above level of umbilicus, lower and back part of neck; *efferents* to lateral glands.

LYMPH GLANDS OF INFERIOR EXTREMITY

Anterior tibial, one on ant. surface of proximal part of interosseous membrane; *afferents* from dorsum of foot and front of leg; *efferents* to popliteal glands. **Popliteal**, in fat of popliteal fossa; *afferents* from sole of foot, back of leg, knee-joint, anterior tibial gland; *efferents* to subinguinal glands. **Inguinal**, just above inguinal ligament, between layers of superficial fascia; not always present; *afferents* from anterior abdominal wall below umbilicus; *efferents* to superficial or deep subinguinal glands.

Superficial subinguinal, just below and parallel to inguinal lig., and along proximal end of vena saphena magna, and on medial side of fossa ovalis (saphenous opening); *afferents* from lower and lateral part of abdominal wall, penis, scrotum, external female genitals and lower $\frac{1}{2}$ of vagina, perineum, anus, anal canal; foot, leg, thigh and buttock; *efferents* to deep subinguinal and iliac glands.

Deep subinguinal, at medial side of proximal end of femoral vein, and one in femoral (crural) canal; *afferents* from deep parts of thigh, penis or clitoris; inguinal, superficial subinguinal and popliteal glands; *efferents* to iliac glands.

LYMPH GLANDS OF ABDOMEN AND PELVIS

Inferior epigastric, along inf. epigastric art.; *afferents* from adjacent parts, including umbilicus; *efferents* to ext. iliac glands.

Iliac, arranged around external and common iliac arteries. *Afferents* to **external iliac glands** from inguinal and subinguinal glands, deep parts of abdominal wall below umbilicus, adductor muscles, neck of bladder, prostate, urethra, deep parts of penis, cervix uteri, upper part of vagina. *Efferents* to **common iliac glands**, and from these to lumbar glands. **Hypogastric**, along hypogastric (internal iliac) artery and its branches; *afferents* from pelvic viscera, deep parts of buttock and back of thigh; *efferents* to common iliac glands. **Vesical**, in retro-pubic fat and along umbilical art.; *afferents* from bladder; *efferents* to ext. iliac glands. **Ano**

rectal, in wall of rectal ampulla ; *afferents* from rectum and upper part of anal canal ; *efferents* to inf. mesenteric glands. **Para-uterine**, in broad lig., at side of cervix ; *afferents* from cervix ; *efferents* to hypogastric glands. **Sacral**, along medial side of anterior sacral foramina ; *afferents* from bones and ligaments, uterus, vagina, prostate, rectum ; *efferents* to hypogastric or common iliac glands.

Lumbar lie along aorta and inf. v. cava, and on psoas, quadratus lumborum and crura of diaphragm ; *afferent* from lower limbs, anterior abdominal wall, pelvic viscera, external genitals, through glands mentioned above, from abdominal alimentary canal through visceral glands, from posterior abdominal wall, testes, ovaries, uterine tubes, body of uterus, kidneys, suprarenals. *Efferents* from pre-aortic glands join intestinal trunk, from lateral aortic and retro-aortic glands join lumbar and retro-aortic trunks. These trunks end in cisterna chyli.

Posterior and anterior left gastric, on crus of diaphragm and in lesser omentum, along left gastric artery (coronary) and around cardiac end of stomach (**para-cardial**) ; *afferents* from stomach ; *efferents* to pre-aortic glands around celiac artery (**celiac** or **middle supra-pancreatic glands**).

Right gastro-epiploic, in greater omentum, along right gastro-epiploic artery ; *afferents* from stomach ; *efferents* to **subpyloric glands**, on the end of gastro-duodenal artery, which send *efferents* to celiac glands. **Hepatic**, in porta hepatis (portal fissure) and right border of lesser omentum ; *afferents* from liver, gall-bladder, duodenum, stomach, pancreas ; *efferents* to celiac glands. **Right supra-pancreatic**, on hepatic art. in right gastro-pancreatic fold ; *afferents* from liver and pyloric part of stomach ; *efferents* to celiac glands. **Pancreatico-lienal (splenic)** (include **left supra-pancreatic**), along upper border and behind pancreas and in gastro-splenic ligament (omentum) and lienorenal ligament ; *afferents* from stomach, pancreas, spleen ; *efferents* to celiac glands.

Mesenteric, between 100 and 200, scattered between layers of mesentery proper ; *afferents* from small intestine, cæcum, vermiform process, ascending, transverse, and part of descending colon ; *efferents* unite to form *common intestinal trunk*, which ends in cisterna chyli. **Meso-colic**, in transverse meso-colon ; **ileo-colic**, **right colic**, in relation to arteries of same name and their branches ; **inferior mesenteric** (including **rectal**), along left colic, sigmoid and superior hæmorrhoidal arteries. **Epicolic**, in appendices epiploicæ ; **para-colic**, along medial borders of ascending, descending and iliac colon, upper border of transverse colon and attached border of pelvic colon, drain these parts of intestine and send lymph on, through glands on vessels mentioned above, to mesenteric glands on stem of sup. mesenteric art., and thence to common intestinal trunk, those from left side going also to lumbar glands and left lumbar trunk.

Appendicular, in mesentery of vermiform process, receives some *afferents* from vermiform process, and is said to receive some from right ovary.

Hæmal lymph glands are found in various parts, especially along abdominal aorta. They resemble lymph glands, but some of their sinuses contain blood and communicate with blood-vessels.

LYMPH GLANDS OF THORAX

Intercostal, in posterior parts of intercostal spaces; *afferents* from post. parts of thoracic walls and parietal pleura; *efferents* from glands in upper spaces end in post. mediastinal glands or in thoracic duct or right lymphatic duct; from glands in lower spaces descend to cisterna chyli. **Sternal**, along int. mammary art.; *afferents* from ant. thoracic and abdominal walls, medial part of mammary gland, anterior part of diaphragm, anterior diaphragmatic glands; *efferents* to anterior mediastinal and lower deep cervical glands, thoracic or right lymphatic duct. **Diaphragmatic: anterior**, behind xiphoid process and 7th costal cartilages; *afferents* from anterior part of diaphragm and of upper surface of liver; *efferents* to sternal glands. **Middle**, at sides of base of pericardium; *afferents* from middle part of diaphragm and upper surface of liver; *efferents* to posterior mediastinal glands. **Posterior**, behind diaphragm, connect posterior mediastinal with lumbar glands. **Anterior mediastinal**, in ant. mediastinum and anterior part of superior; *afferent* from liver, diaphragm, lower sternal glands, heart, pericardium, thymus, thyreoid gland; *efferents* to lower deep cervical glands and thoracic and right lymphatic ducts. **Posterior mediastinal**, along aorta and œsophagus; *afferent* from pleura, pericardium, œsophagus, diaphragm, liver, diaphragmatic glands; *efferent* to bronchial glands, thoracic and right lymphatic ducts. **Tracheal, bronchial, and broncho pulmonary**, at lower end of trachea and on bronchi, and their branches; *afferents* from trachea, bronchi, lungs, visceral pleura, heart, thymus; *efferents* to thoracic and right lymphatic ducts, and inferior deep cervical glands.

NEUROLOGY

THE **nervous system** brings all parts of the body into association with one another. It consists of a central and a peripheral system.

Central nervous system consists of (1) the **Brain** or **Encephalon**, situated in the cranial cavity, and (2) the **Spinal medulla** (spinal cord), situated in the vertebral canal. Brain and spinal medulla are continuous with each other at the foramen magnum. They are built up of nerve cells, nerve fibres, and a supporting tissue called neuroglia. The brain consists of (1) cerebrum (including mesencephalon), (2) cerebellum, (3) pons, (4) medulla oblongata, the last three occupying the posterior cranial fossa, below tentorium cerebelli.

Peripheral nervous system consists of (1) cerebral and spinal nerves and their ganglia, and (2) the sympathetic system.

The **brain** is divided into rhombencephalon and cerebrum.

The **rhombencephalon** is derived from the posterior primary cerebral vesicle and is divided into myelencephalon and metencephalon.

The myelencephalon is the **medulla oblongata**. The metencephalon consists of **pons** and **cerebellum**.

The **cerebrum** is divided into **mesencephalon** or **mid-brain**, derived from the middle primary vesicle, and the **prosencephalon**, derived from the anterior primary vesicle. The prosencephalon is divided into **diencephalon** and **telencephalon**.

Diencephalon consists of the **pars mamillaris hypothalami** and **thalamencephalon**. **Pars mamillaris hypothalami** consists of mamillary bodies and walls of 3rd ventricle below sulcus hypothalamicus. **Thalamencephalon** includes: (1) *thalamus*;

(2) *metathalamus*, which consists of the geniculate bodies ; and
 (3) *epithalamus*, comprising pineal body, habenulæ, habenular commissure, trigona habenularum.

Telencephalon includes : (1) **rhinencephalon**—olfactory tract, etc. ; (2) **pars optica hypothalami**—tuber cinereum, infundibulum, hypophysis, optic tracts and chiasma, and the lamina terminalis ; (3) **cerebral hemispheres**.

Nerve ganglia are made up of nerve cells and nerve fibres. **Nerves** contain nerve fibres, which conduct impulses. Those which convey impulses from cells of the brain or spinal medulla to the tissues of the body are called **efferent**, *e.g.* to muscles, glands. Those which convey impulses to cells in the brain and spinal medulla are called **afferent**.

There are 12 pairs of cerebral nerves and 31 pairs of spinal nerves. Each **spinal nerve** contains both afferent and efferent fibres, and is attached to the spinal medulla by two roots—a **posterior**, composed of afferent fibres, and an **anterior**, composed of efferent fibres. Of the **cerebral nerves** some are wholly efferent (3rd, 4th, 6th, 11th, 12th) ; some are devoted exclusively to organs of special sense (1st, 2nd, 8th) ; and some are mixed nerves (5th, 7th, 9th, 10th).

Sympathetic nervous system innervates viscera, glands and blood-vessels, and is connected with cerebro-spinal system by numerous communicating branches. It consists of (1) **two sympathetic trunks**, each made up of a longitudinal series of ganglia connected by strands of nerve fibres, placed on ventral aspect of vertebral column. (2) **Three large plexuses** containing ganglia.—**Cardiac plexus**, on bifurcation of trachea ; **cœliac plexus**, around cœliac artery and on crura of diaphragm ; **hypogastric plexus**, on sacral promontory, between common iliac arteries. (3) Numerous plexuses on walls of arteries and in walls of viscera. These also contain small ganglia.

CENTRAL NERVOUS SYSTEM

MEDULLA SPINALIS

Spinal medulla (spinal cord), more or less cylindrical, 18 inches long. Begins at for. magnum, where it is continuous with medulla oblongata ; occupies but does not nearly fill vertebral canal ; is surrounded by 3 membranes : dura mater, arachnoid, pia mater ; tapers to an end at lower

border of 1st lumbar vertebra. Terminal part is called *conus medullaris*, from which a glistening fibrous thread, called *filum terminale*, is continued downwards to be attached to dorsum of coccyx. *F. terminale* consists chiefly of fibrous tissue continuous with pia mater, but the central canal, surrounded by a little grey matter and a few white fibres, is continued into it for 1 to 3 inches. *Filum* pierces tube of *dura* at 3rd sacral vertebra and receives a sheath from it.

Spinal medulla presents 2 enlargements, corresponding to position of attachment of large nerves supplying upper and lower limbs:—*Intumescencia cervicalis* begins near upper end, is largest opposite 5th or 6th cervical vertebra, ends at 2nd thoracic. *Intumescencia lumbalis* begins at 10th thoracic vertebra, is largest opposite 12th, and then rapidly subsides.

31 pairs of nerves are attached to spinal medulla: 8 cervical, 12 thoracic, 5 lumbar, 5 sacral, 1 coccygeal; and spinal medulla is divided into *regions*, *cervical*, etc., corresponding to these. These regions do not lie opposite corresponding regions of vertebral column, as the spinal medulla is shorter than the column. The part to which any one pair of nerves is attached is called a *segment*: 1st cervical segment, 2nd thoracic, etc. These are marked off from one another only by attachments of nerve roots.

Grey matter is in the interior of spinal medulla; white matter is on the outside.

Grey matter has the form of two longitudinal fluted columns united across median plane by a band called *substantia grisea centralis* (central grey substance), tunnelled by *central canal*, which divides it into *post. commissure* and *ant. grey commissure*. Part dorsal to level of commissure is called *columna grisea posterior*; ventral part, *c. grisea anterior*, and a projection opposite commissure, seen best in thoracic region, is called *c. grisea lateralis* (*post.*, *ant.* and *lateral grey columns*). These columns are often called *horns* when seen in cross section, and the free extremity of each is called the *head*.

Substantia gelatinosa Rolandi is a Λ -shaped mass of grey matter situated on dorsal edge of *post. column*. It is more translucent on section than rest of grey matter.

Formatio reticularis, the intermixture of grey and white matter in concavity between *ant.* and *post. columns*, is seen best in cervical region.

In cervical region ant. column is larger than posterior. In thoracic, both are small; in lumbar both are large and amount of surrounding white matter is relatively small.

Fila radicularia of anterior (motor) roots of spinal nerves arise in anterior column (horn), pass forwards and emerge along a broad linear strip on ventral surface of spinal medulla. Fila radicularia of post. (sensory) roots enter along a narrow linear groove, called *sulcus lateralis posterior*, and end in relation to posterior column.

Halves of spinal medulla are incompletely separated from each other by a fissure, a septum, and a sulcus.

Anterior median fissure.—Wide and shallow, less than $\frac{1}{3}$ of thickness of spinal medulla, except in lower part; occupied by fold of pia mater; is separated from grey commissure by band of white matter called *commissura anterior alba*.

Posterior median septum, a thin layer of neuroglia, extends from surface to the grey commissure, along whole length of spinal medulla, and corresponds to $\frac{1}{2}$ its thickness, except at lower end; forms floor of **posterior median sulcus** of spinal medulla.

White matter of each half of spinal medulla is subdivided by columns of grey matter and fibres of roots of nerves into *funiculi*, *posterior*, *lateralis* and *anterior*. In cervical and thoracic regions the posterior funiculus is divided into fasciculus gracilis medially and f. cuneatus laterally by a septum of pia mater whose position on surface is indicated by *sulcus intermedius posterior*. Anterior and lateral funiculi are often referred to under one name—antero-lateral funiculus.

Some fibres in white matter convey ascending impulses, others descending; and they are grouped into *fasciculi* or *tracts* more or less distinct from one another. The fasciculi are represented best in upper part of spinal medulla, where descending fibres have not yet come to an end and ascending tracts have been fully formed.

FASCICULI OR TRACTS OF SPINAL MEDULLA

(see also p. 354)

Funiculus Posterior.—Fasciculus gracilis (Goll) medially. Fasciculus cuneatus (Burdach) laterally. Both are ascending and are derived from post. nerve roots. **Comma tract**, in substance of f. cuneatus, derived from descending fibres from post. nerve roots, and

intersegmental fibres. Other fibres connecting different segments of spinal medulla are found separating f. gracilis and cuneatus from grey commissure, and on medial and posterior surfaces of f. gracilis. They constitute the **fasciculus posterior proprius**.

Funiculus Lateralis.—**Fasciculus lateralis proprius** (lateral basis bundle); intersegmental fibres; in concavity between ant. and post. columns (horns). **F. cerebro-spinalis lateralis** or **pyramidalis lateralis** (crossed pyramidal); descending, motor; ventral to posterior column (horn), lateral to f. lateralis proprius, dorsal to rubro-spinal and antero-lateral superficial fasciculus (Gowers), separated from surface by f. cerebello-spinalis (direct cerebellar). **F. postero-lateralis** (Lissauer); in front of or surrounding post. nerve roots; intersegmental, or ascending from post. nerve roots. **F. cerebello-spinalis** (direct cerebellar), ascending from cells at base of posterior column; at surface of spinal medulla, lateral to lateral pyramidal, dorsal to antero-lateral superficial and partly mingled with it. **F. antero-lateralis superficialis**, ascending from cells in posterior column to cerebellum, superior corpora quadrigemina and thalamus; at surface of spinal medulla, ventral to cerebello-spinal and lateral pyramidal, superficial to rubro-spinal and f. anterior proprius, extending into anterior funiculus anteriorly. **Rubro-spinal** or **pre-pyramidal tract**, descending from red nucleus of opposite half of mesencephalon to end round cells at base of ant. column; ventral to lateral pyramidal, between antero-lateral superficial and lateralis proprius. **Ponto-spinal tract**, descending, scattered in lateral funiculus. **Spino-tectal** and **spino-thalamic fibres** ascend, not as fasciculi but scattered in the lateral funiculus, from post. column of opposite side to corpora quadrigemina and to thalamus respectively.

Funiculus Anterior.—**Fasciculus anterior proprius** (ant. basis bundle), intersegmental; rolled round anterior column (horn), continuous, at the side, with proprius lateralis, and, above, with medial (posterior) longitudinal bundle of medulla oblongata and pons. **F. cerebro-spinalis anterior** or **pyramidalis anterior** (direct pyramidal): descending, motor, from cerebral cortex; along anterior median fissure. **Tecto-spinal tract**, descending from opposite superior corpus quadrigeminum; and **vestibulo-spinal tract**, from nucleus of Deiters and Bechterew,—both lie at surface of ant. funiculus and end around cells of ant. column.

Vessels of Spinal Medulla.—**Arteries**: anterior and posterior spinal branches of vertebral, reinforced by lateral spinal branches of vertebral, ascending and deep cervical, intercostal and lumbar, form arterial columns in anterior median fissure under linea splendens, and in front of and behind posterior nerve roots. These columns anastomose with each other in pia mater. **Veins** form a plexus drained into 6 longitudinal spinal veins placed in median plane ventrally and dorsally, and in relation to ant. and post. nerve roots. They are

continuous above with veins of medulla oblongata, and communicate with veins of vertebral canal by branches which run along nerve roots. **Lymphatics** end in deep cervical, intercostal and lumbar glands.

ENCEPHALON OR BRAIN

Brain, about 3 lbs. in weight (1360 grm.), almost fills cranial cavity, and is surrounded by dura mater, arachnoid and pia mater.

When viewed from above the **cerebral hemispheres** are seen, and between them the **longitudinal fissure**, at the bottom of which the **corpus callosum** is found, if the hemispheres are pulled apart.

When viewed from below, various parts are seen :—

Anteriorly are the orbital surfaces of **frontal lobes** of the hemispheres ; between them the longitudinal fissure ; and, if that is widened, the anterior end—**genu** and **rostrum**—of **corpus callosum** is found. Near median plane, on orbital surface, is the **olfactory bulb**, continuous posteriorly with **olfactory tract**, which divides into **medial** and **lateral roots** or **striæ**, with sometimes an intermediate stria between them. Posterior to frontal lobe is the **temporal lobe**. Cleft between them is the stem of **fissura lateralis** (Sylvius). On medial side of temporal lobe is the **uncus** of **gyrus hippocampi**.

Posteriorly are the halves of **cerebellum** ; between them posteriorly is **medulla oblongata**, and uniting them anteriorly is the **pons**. At side of median plane of medulla oblongata is **pyramid**, a longitudinal elevation consisting of motor fibres emerging from pons ; lateral to it is the **olive** ; dorso-lateral to olive is **restiform body**, which connects medulla oblongata with cerebellum. Pons is continued into cerebellum on each side as **brachium pontis** (**middle cerebellar peduncle**), lying on which is a semi-detached part of cerebellum called **flocculus**.

Above pons are the **cerebral peduncles** (**crura cerebri**) ; part of each seen is **basis pedunculi** (**crusta**), diverging from its fellow to sink into hemisphere and become continuous with internal capsule ; curving round upper end of basis, and partly hidden by uncus, is the **optic tract**, which ends anteriorly by joining **optic chiasma**, from which **optic nerve** passes antero-laterally to optic foramen. Chiasma lies at posterior end of part of longitudinal fissure seen in this view. If chiasma is pulled down and back, the thin, easily torn **lamina terminalis**

(cinerea) is seen stretching up to rostrum of corpus callosum ; it forms a great part of ant. wall of 3rd ventricle.

Interpeduncular fossa is bounded posteriorly by upper border of pons, postero-laterally by basis pedunculi, antero-laterally by optic tract, anteriorly by chiasma. Within it are structures which lie in floor of 3rd ventricle : from behind forwards, **posterior perforated substance** (spot); **corpora mamillaria**, two small, pea-like bodies ; **tuber cinereum**, a slight elevation behind chiasma, continuous with **infundibulum** or stalk of **hypophysis** (pituitary body), which lies on sella turcica of sphenoid under diaphragma sellæ, and has been detached in removal of brain.

Vallecula Sylvii is a space lateral to optic chiasma. Int. carotid artery ends in it. Its floor is **anterior perforated substance** (spot), which is continuous above with basal ganglia. It is bounded medially by optic tract, chiasma and nerve, anteriorly by roots of olfactory tract, postero-laterally by uncus ; laterally it leads into fissura lateralis (Sylvius).¹

SUPERFICIAL ORIGIN OR ATTACHMENT OF NERVES, AND THEIR EXIT FROM CRANIAL CAVITY

1. **Olfactory** : olfactory bulb ; foramina in lamina cribrosa of ethmoid. 2. **Optic** : chiasma ; optic foramen. 3. **Oculo-motor** : oculo-motor sulcus on medial surface of basis pedunculi ; superior orbital (sphenoidal) fissure. 4. **Trochlear** : anterior medullary velum (valve of Vieussens) at medial side of brachium conjunctivum (sup. cerebellar ped.) (origin not seen on the base) : sup. orb. fissure. 5. **Trigeminal** : junction of pons and brachium pontis (middle peduncle) ; *ophthalmic division* through sup. orb. fissure ; *maxillary* through for. rotundum ; *mandibular* and motor root through for. ovale. 6. **Abducent** : lower border of pons at upper end of pyramid ; superior orbital fissure. 7. **Facial**, and 8. **Acoustic** (auditory) and *N. intermedius* (sensory root of facial) : lower border of pons, at upper end of restiform body ; internal acoustic meatus. 9. **Glosso-pharyngeal**, and 10. **Vagus** : postero-lateral sulcus, between olive and restiform body ; jugular foramen. 11. **Accessory** : side of medulla oblongata below 9 and 10, side of medulla spinalis (spinal cord) between ant. and post. roots of spinal nerves as low as 5th cervical ; jugular foramen. 12. **Hypoglossal** : groove between olive and pyramid ; hypoglossal canal (ant. condyloid).

¹ The "vallecula" defined here is only the medial end of the vallecula or fossa which develops into fissura lateralis.

MEDULLA OBLONGATA

One inch long ; conical in shape, large end above ; extends from lower border of pons to foramen magnum, where it is continuous with spinal medulla. Lies in vallecule cerebelli, posterior to basilar part of occipital bone. Vertebral arteries lie at sides, below, in front of nerve roots ; converge and meet anteriorly at lower border of pons.

Lower half has **central canal**, continuous with that of medulla spinalis (spinal cord). Central canal, traced upwards, approaches dorsal surface, expands, and in upper half of medulla oblongata, it forms lower part of 4th ventricle, which is closed dorsally only by layer of ependyma, covered by supporting layer of pia mater.

Anterior median fissure begins above in a pit called *foramen cecum*, at lower border of pons ; and is interrupted below by *decussatio pyramidum*, i.e. the interlacing of fibres of pyramids crossing from one side to the other.

Posterior median fissure is found only in lower part of medulla oblongata ; traced upwards, it ends where central canal comes to surface, its lips being thrust apart to become continuous with margins of fossa rhomboidea. **Sulcus lateralis anterior** : between pyramid and olive above, where fila of hypoglossal nerve emerge through it ; in line with anterior nerve roots below, and fila of anterior root of 1st cervical emerge through it. **Sulcus lateralis posterior** : posterior to olive and separated from it by part of antero-lateral superficial fasciculus (Gowers') above, where 9th and 10th nerves are attached ; in line with posterior lateral groove of spinal medulla below, and fibres of 11th emerge through it. These lateral sulci divide each half of medulla oblongata into 3 areas :—

Posterior Area.— **Funiculus gracilis** (Goll) medially, continuous with fasciculus gracilis of spinal medulla ; ends above, at lower end of 4th ventricle, in a prominence called **clava**, produced by underlying *nucleus f. gracilis*. **Funiculus cuneatus**, continuous with f. cuneatus of spinal medulla, ends above in prominence called **cuneate tubercle**, poorly marked in adult ; produced by *nucleus f. cuneati*. **Tuberculum cinereum** (tubercle of Rolando), posterior to roots of accessory nerve, formed by tractus spinalis (spinal root of V.) spread out over an enlargement of its nucleus, which is continuous with sub. gelatinosa Rolandi of spinal medulla. **Corpus restiforme**, large and prominent bundle. Begins above

clava and cuneate tubercle ; forms lateral boundary to medullary part of fossa rhomboidea ; extends up to touch lower border of dorsal surface of pons, and then turns sharply backwards into cerebellum.

Funiculus Lateralis (Lateral Area).—Olive, an oval eminence occupying upper part ; produced by underlying *nucleus olivaris inferior*. **Antero-lateral superficial fasciculus** (Gowers') of spinal medulla is continued up to olive. Most of it dips under olive ; remainder runs up along post. border. **F. cerebello-spinalis** (direct cerebellar) of spinal medulla lies in lower part of area ; above, it inclines dorsally over posterior lateral sulcus and tractus spinalis, and joins restiform body. Under cover of these, **f. lateralis proprius** (lateral basis bundle) and spino-tectal and -thalamic fibres are continued up into medulla oblongata, and rubro- and ponto-spinal tracts descend to spinal medulla. Lateral area of medulla oblongata therefore corresponds, to a large extent, to lateral funiculus of medulla spinalis, but f. pyramidalis lateralis of medulla spinalis is crossing to opposite pyramid.

Anterior Area.—**Pyramid**, composed of motor fibres descending from cortex of brain to spinal medulla. At lower part of medulla oblongata the majority cross to opposite side in the decussation and become f. pyramidalis lateralis (crossed pyramidal). The most lateral fibres descend as f. pyramidalis anterior (direct pyramidal) of same side, and a few (homolateral) join fibres which have crossed from other side.

External arcuate fibres, derived from nuclei f. gracilis and cuneati of opposite side, emerge on medial side, on lateral side, and through pyramid ; arch over surface of olive and below it, and join restiform body. *Dorsal superficial arcuate fibres* arise in nuclei f. gracilis and cuneati but end in restiform body of same side.

Arteries of Medulla Oblongata.—Branches from vertebrals. **Veins** form plexus drained by inf. petrosal sinus, and by vein through hypoglossal canal (ant. condyloid) to pharyngeal plexus.

Internal Structure.—Grey matter surrounding central canal of medulla oblongata is a continuation of grey commissures of medulla spinalis, and, in addition, the continuation of bases of anterior and posterior grey columns. When canal opens into 4th ventricle the grey matter is spread out over fossa rhomboidea (floor of 4th ventricle).

As lateral pyramidal fasciculus crosses from anterior area of medulla oblongata to lateral funiculus of opposite half of spinal medulla, it cuts through anterior column (horn) and separates head from base.

Base forni nucleus of 12th nerve. It remains joined on to ventral wall of canal, and when 4th ventricle is reached it lies in its floor near median plane. Detached head, traced upwards, is shoved by the pyramid into lateral area of medulla oblongata and divides into medial and lateral columns, namely, **nucleus ambiguus** and **nucleus lateralis**. When they reach the olive it pushes them still further posteriorly and laterally, and n. lateralis becomes diffuse and disappears, but n. ambiguus persists to upper end of medulla oblongata. Some fila of spinal root of accessory nerve and of motor root of 1st cervical arise from n. lateralis. Cerebral roots of accessory nerve and motor fibres of vagus and glosso-pharyngeal arise from n. ambiguus.

As central canal approaches dorsal surface, the funiculus gracilis and f. cuneatus become broader and less deep, and posterior columns (horns) are bent laterally. Substantia gelatinosa Rolandi enlarges, lies near surface, forming tuberculum cinereum, and is covered superficially by tractus spinalis (spinal root) of trigeminal nerve, whose fibres end in it. From medial (now dorsal) side of column the **nuclei of funiculus gracilis** and **f. cuneatus** appear as projections and these funiculi end in them. **Internal arcuate fibres** arise in these nuclei, arch anteriorly and medially to decussate ventral to central canal. They cut through the modified posterior horn, leaving its base attached to dorso-lateral wall of central canal, and when 4th ventricle is reached the continuation of the base lies in lateral part of floor. There, it forni sensory nuclei of vagus and glosso-pharyngeal and part of nucleus of vestibular nerve.

Decussation of internal arcuate fibres is called **decussatio lemniscorum**. It occurs dorsal to and above decussation of pyramids. Having decussated, most of the fibres turn sharply upwards and form the *lemniscus medialis* (mesial fillet), near median raphe of medulla oblongata; but some pass forwards as external arcuate fibres (see also pp. 326, 355).

Nucleus arcuatus lies on anterior and medial aspects of pyramid, covered by external arcuate fibres, some of which are renewed in it. It is continuous above with nuclei pontis.

Inferior olivary nucleus is a crumpled bag of grey matter within the olive. Its *hilum* looks medially. Out of it **cerebello-olivary fibres** proceed across upper part of medulla oblongata, decussate at median plane; pass onwards, some through and some around opposite nucleus, forming a sheath for it; turn dorsally, traverse tractus spinalis (spinal root of trigeminal), breaking it up into bundles; enter deep aspect of restiform body and form its chief bulk. They end around cells of cortex of hemisphere and vermis of cerebellum and nucleus dentatus; some may arise in cortex of cerebellum and end in olivary nucleus. *Dorsal and medial accessory olivary nuclei* are small, and placed, the one dorsal to hilum, the other medial to it.

Restiform body (inferior cerebellar peduncle) lies on dorso-lateral aspect of upper part of medulla oblongata; forms lateral boundary

of lower part of 4th ventricle, and lateral recess extends laterally over it. At lower border of pons it is embraced by vestibular and cochlear nerves as they separate. It ascends for short distance on lateral part of dorsal surface of pons. Bending sharply backwards, it enters cerebellum, between brachium pontis and brachium conjunctivum, and spreads out fan-wise, over nucleus dentatus, towards vermis. It contains (1) cerebello-olivary fibres; (2) dorsal superficial arcuate fibres from nuclei f. gracilis and cuneati of same side; (3) ext. arcuate fibres from nuclei f. grac. and cun. of opposite side; (4) fasc. cerebello-spinalis (direct cerebellar); (5) a few fibres from vestibular nerve, and others connecting cerebellum with pyramid, lemniscus, roots of motor cerebral nerves, and with nuclei of Deiters and Bechterew.

Medial Longitudinal Fasciculus (Posterior Longitudinal Bundle).—Fasciculus anterior proprius of spinal medulla (ant. basis bundle), like f. lateralis proprius, consists of many series of short fibres running up and down to connect grey matter of different segments. As it enters medulla oblongata it lies on medial side of detached head of ant. horn. Above level of decussation it has come to lie dorsal to pyramid, in relation to grey matter of central canal. Here the decussation of lemnisci takes place ventral to it, so that it comes to lie dorsal to the lemniscus (fillet), under grey matter of floor of 4th ventricle, close to median plane; and it is named medial longitudinal fasciculus. This compact bundle enters pons and maintains this position and relation to grey matter. Entering mesencephalon, it lies on ventral surface of grey matter around aqueductus cerebri (Sylvius), and it ends in nucleus in posterior part of side wall of 3rd ventricle. It is composed of fibres which enter it from nuclei of cerebral (cranial) nerves, divide, run up and down, and leave it to end in nuclei of other cerebral nerves. Some of its fibres come from other sources, but their connections are more doubtful.

Areas of Flechsig.—On transverse section each half of upper part of medulla oblongata is seen divided into 3 segments—ventral, lateral and dorsal—by fibres of xii, and of ix, and x. as they pass from their nuclei to the surface.

Contents of Ventral Segment.—Substantia reticularis alba, pyramid, arcuate and medial accessory olivary nuclei. *Lateral Segment.*—Greater part of substantia reticularis grisea, inf. olivary and dorsal accessory olivary nuclei, nucleus lateralis and n. ambiguus. *Dorsal Segment.*—Restiform body, upper part of nucleus f. cuneati, descending root of vestibular n. and its nucleus, tractus spinalis and solitarius and their nuclei.

Substantia reticularis alba and **grisea** make up that part of medulla oblongata which lies dorsal to pyramid and olive. Roots of hypoglossal nerve pass ventrally between them. **Transverse fibres** in them are cerebello-olivary and internal arcuate. **Longitudinal fibres in alba** are lemniscus, medial longitudinal bundle, tecto-spinal tract; **in grisea**, continuation of f. lateralis proprius, f. antero-

lateralis superficialis (Gowers'), rubro-spinal, ponto-spinal, vestibulo-spinal tracts, and tractus solitarius; spino-tectal and spino-thalamic fibres (see also pp. 354-357).

Nuclei of Nerves. See Cerebral (Cranial) Nerves, p. 381.

PONS

Lies ventral to cerebellum, and dorsal to basilar part of occipital bone and dorsum sellæ. Cerebral peduncles (crura cerebri) emerge from it above, medulla oblongata joins it below. Transverse sections show that it consists of a small **pars dorsalis** and a large **pars basilaris**. **Dorsal part** forms upper part of fossa rhomboidea (floor of 4th ventricle).

Basilar part, large and convex, is seen from front. At median plane is **sulcus basilaris** for basilar artery, bounded by ridges produced by pyramidal fasciculi in the interior. Trigeminal nerve is attached to it laterally, and part beyond the nerve is called **brachium pontis** (middle cerebellar peduncle) and sinks backwards into cerebellum between lips of horizontal sulcus.

Vessels of Pons. - **Arteries**: branches from basilar. **Plexus of veins** drains into basilar vein, sup. petrosal sinus, cerebellar veins.

Contents. **Basilar part** consists of: (1) **Transverse fibres** which arise (*a*) in cerebellar cortex and end in nuclei pontis on both sides of median plane; (*b*) in nuclei pontis on one side, cross median plane and end in cerebellar cortex. Some fibres of medial longitudinal bundle pass to cerebellum through brachium. (2) **Longitudinal fibres** are pyramidal fibres which have descended through mid capsule and basis pedunculi (crusts) from cerebral cortex. Most of them end in nuclei pontis, but some are continued as pyramid of medulla. (3) **Nuclei pontis** are collections of grey matter packed amongst intersecting bundles of transverse and longitudinal fibres.

Dorsal part is bounded laterally by restiform body (p. 327) below, brachium conjunctivum (sup. cerebellar peduncle, p. 331) above. Lemniscus lateralis (lateral fillet, p. 392) forms a broad elevation on lateral surface of upper part of brachium. These and the following contents are described elsewhere: Lemniscus medialis (p. 356), medial longitudinal bundle (p. 328), corpus trapezodeum (p. 392), tecto-spinal tract (p. 355), antero-lateral superficial fasciculus (Gowers') and spino-tectal and spino-thalamic fibres (p. 356), sup. olivary nucleus (p. 392), nuclei and fibres of 5th, 6th, 7th, 8th nerves (pp. 384, 389, 391, 392).

CEREBELLUM

Lies dorsal to pons and medulla oblongata, below posterior parts of cerebral hemispheres, from which it is separated by

tentorium cerebelli. In relation to surface of head, it lies below a line drawn nearly horizontally from ext. occipital protuberance to base of mastoid temporal.

Closely set, curved parallel laminae on its surface give it a characteristic foliated appearance.

It is connected with cerebrum by brachia conjunctiva, with pons by brachia pontis, with medulla oblongata by restiform bodies.

Consists of 2 **hemispheres** united by median portion, called **vermis**, which is shorter than hemispheres, leaving notches between them: **incisura anterior**, occupied by dorsal part of mesencephalon; **incisura posterior**, occupied by falx cerebelli.

Sulcus horizontalis separates **superior surface** of hemisphere from **inferior**.

Superior surface of vermis is not marked off from hemisphere. It sends a tongue-like prolongation, called **lingula**, forwards over anterior medullary velum; and it is divided, further, into parts directly continuous with lobules of upper surface of hemisphere on each side, named from before backwards:—

Vermis	Lobules of Hemisphere
Lingula	
Lobulus centralis . . .	Ala lobuli centralis.
Monticulus { culmen . . .	Pars anterior } Lobulus
{ declive . . .	Pars posterior } quadrangularis.
Folium vermis . . .	Lobulus semilunaris superior.

Hemispheres are separated below by **vallecula cerebelli**. Inferior part of vermis projects into it, and is separated from hemisphere, on each side, by **sulcus vallecule**; and is divided into parts connected, across floor of sulcus, with lobules of hemisphere. These are named from before backwards:—

Vermis	Lobules of Hemisphere
Nodulus...—Pedunculus flocculi—...	Flocculus.
Uvula	Tonsilla.
Pyramid	Lobulus biventer.
Tuber vermis	{ Lobulus gracilis.
	{ Lobulus semilunaris inferior.

Tonsilla is the rounded nodular part on medial side of lower surface; concavity in which it lies is called *nidus avis*. **Flocculus** is the small semi-detached part in front, lying on brachium pontis. Its **peduncle** is a narrow white stalk connected with nodulus by means of posterior

(inferior) medullary velum. The names of the other subdivisions of the surfaces of the cerebellum have been merely tabulated above; they are not of sufficient importance to require further description.

Posterior medullary velum is a thin, translucent sheet of fibres, prolonged out of white medullary substance of vermis above nodule; it curves downwards in front of nodule, and ends in a free, thickened crescentic edge. Laterally it extends from nodule to peduncle of flocculus and is hidden by tonsil.

Corpus medullare is the central white substance of cerebellum. From it sheets of fibres, called **laminæ medullares**, project into folia of cerebellum, forming their cores; and these laminæ are covered by **substantia corticalis** or grey matter seen on surface. Arbor-escence of sagittal sections of cerebellum is called **arbor vitæ**. **Nucleus fastigii** (roof nucleus) is a small nucleus in white substance of vermis near median plane. **Nucleus globosus** and **n. emboliformis** are small collections placed a little more laterally.

Nucleus dentatus lies in white substance of cerebellar hemisphere, near vermis, above nidus avis. It is a large crumpled sheath, possessing a hilum directed upwards and medially, out of which proceed most of fibres of brachium conjunctivum.

Anterior medullary velum is a thin sheet of fibres prolonged out of white substance of vermis; lies between brachia conjunctiva and connects their dorsal edges; ends above at inf. corpora quadrigemina, and is connected to groove between them by band of fibres called *frenulum veli*. Trochlear nerve emerges through it between frenulum and brachium. Lingula lies on lower part on its dorsal surface. Some fibres of antero-lateral superficial fasciculus (Gowers') descend to cerebellum in it. Both ant. and post. vela share in formation of roof of 4th ventricle.

Brachium conjunctivum (sup. cerebellar peduncle) arises mainly in nucleus dentatus; a few fibres come from cerebellar cortex; some fibres of antero-lateral superficial (Gowers') tract are contained in it. Leaving cerebellum, its ventral border unites with dorsal part of pons, and it passes upwards, sinking deeper in substance of pons, and converging towards its fellow, to which it is united by anterior medullary velum. It forms upper lateral boundary and part of roof of 4th ventricle. Anterior part of upper surface of cerebellum overlaps it below, and the *lemniscus lateralis* (lateral fillet) lies on its lateral surface above. It disappears into tegmentum of mesencephalon, under cover of inf. corpus quadrigeminum, and straightway begins to decussate with its fellow, ventral to medial longitudinal bundle and grey matter around aqueduct. Decussation is completed at level of upper border of inf. corp. quad. Having crossed, the brachium passes upwards and meets red nucleus. Many fibres end there; the rest proceed onwards encapsulating red nucleus, and most end in thalamus, but some

may pass, in internal capsule, to motor area. When it enters pons some of its fibres are said to turn downwards along medial side of tractus spinalis, and end in motor nuclei of pons and medulla oblongata, and in anterior grey column of spinal medulla. Some fibres which arise in visual centres in opposite thalamus and opposite side of mid-brain cross in mid-brain, and pass to cerebellum in the brachium.

Vessels of Cerebellum.—**Arteries**: posterior inferior cerebellar of vertebral, anterior inf. cerebellar of basilar to *lower surface*; superior cerebellar of basilar to *upper surface*. **Veins**: *superior cerebellar veins* end in v. cerebri magna (Galen), transverse or superior petrosal sinus; *inferior*, in straight sinus, inf. petrosal and occipital sinuses.

VENTRICULUS QUARTUS

A cavity enclosed by cerebellum, pons and medulla oblongata, lined with **ependyma**, a variety of epithelium which lines ventricles of brain, aquæductus cerebri and central canal of medulla oblongata and med. spinalis. The cavity is continuous *below* with central canal of medulla oblongata and spinalis, and *above* with aquæductus cerebri, through which it communicates with 3rd ventricle. Its **roof** is concealed by cerebellum, and is formed, above, by anterior medullary velum and overhanging brachia conjunctiva; below that, by white core of vermis, and, below that, by posterior medullary velum, but *lowest part* of roof consists of ependyma alone. This ependyma and pia mater covering it are perforated by **apertura medialis v. quarti (foramen Magendii)**, through which the ventricle communicates with subarachnoid space. Similar apertures are found in lateral recesses. **Floor** of ventricle is called **fossa rhomboidea**, and is formed by dorsal surface of pons and upper part of medulla oblongata. A thick layer of grey matter is spread over it. Its lower end or angle is called *calamus scriptorius* and leads into central canal of medulla oblongata. Its lateral angles are at the point where restiform body and brachium conjunctivum meet. Here, a prolongation of cavity, called *recessus lateralis*, is carried outwards over restiform body as far as glossopharyngeal nerve. Its **lateral boundaries** are: clava, cuneate tubercle and restiform body, below; brachium conjunctivum, above; and between the two is part of brachium pontis.

A median groove divides floor into symmetrical halves; the striæ medullares (acusticæ) divide each half into a lower

medullary part and an upper pontine part. A Λ -shaped depression, apex of which is upwards and is called *inferior fovea*, divides lower part into 3 areas by means of two sulci diverging from fovea: (1) **trigonum n. hypoglossi**, between depression and median groove, overlies nucleus of 12th nerve; (2) **ala cinerea** (trigonum vagi), between the sulci, overlies a nucleus of 10th and 9th nerves; (3) **trigonum acustici**, between the depression and striæ medullares, overlies nucleus of vestibular nerve. **Eminentia medialis**, a longitudinal elevation, alongside median groove in upper half, is continuous with trigonum hypoglossi below, and is most prominent (*colliculus facialis*) where it overlies nucleus of 6th nerve and ascending part of root of facial nerve. Lateral to it, is a slight depression called **fovea superior**, and above that, at upper angle, is a dark blue spot, called **locus cœruleus**. Nucleus of vestibular nerve produces an elevation called **area acustica**, under striæ medullares, which extends on to trigonum acustici and to lower part of pontine part of fossa.

The part of medulla oblongata forming floor of 4th ventricle is the dorsal surface of its **ventral part**; the **dorsal part** is theependymal roof of lowest portion of ventricle.

The term **isthmus rhombencephali** is applied to the region enclosing highest part of ventricle; it comprises chiefly the anterior medullary velum, brachia conjunctiva, upper part of pons.

MESENCEPHALON OR MID BRAIN

A short stalk, $\frac{3}{4}$ inch long, occupies incisura cerebelli anterior and incisura tentorii; directed obliquely upwards and forwards; connects pons and cerebellum with thalami and cerebral hemispheres. Consists of 4 *corpora quadrigemina*, and of 2 *cerebral peduncles*, which are partly joined together and enclose *aqueductus cerebri* (Sylvii).

Corpora quadrigemina, situated on dorsal surface; separated from one another by crucial groove; overhung by pineal body, pulvinar of thalamus and splenium of corpus callosum. Sup. pair are lower centres for sight, and are called *colliculi superiores*; pineal body lies in groove between them. **Brachium quadrigeminum superius** is a band of fibres extending laterally from each, between pulvinar and medial geniculate body, to join lateral root of optic tract and the **corpus geniculatum laterale**—an ill-defined elevation on lateral part of lower surface of pulvinar thalami. Inferior pair are

connected with hearing, and are called *colliculi inferiores*. **Brachium quadrigeminum inferius**, more obvious than the superior, extends to **corpus geniculatum mediale**—an oval eminence under cover of pulvinar, at upper end of sulcus lateralis of mesencephalon,—and then turns upwards under cover of it into tegmentum, and ends in thalamus.

Superior colliculus consists of **stratum zonale**, a superficial white layer of fibres from optic tract; **stratum griseum**, grey matter; **stratum opticum**—grey matter and white fibres of optic radiation; **stratum lemnisci**—grey matter and fibres of lemnisci. Other fibres connected with colliculus are pyramidal motor fibres, tecto-spinal tract, spino-tectal fibres, and fibres connecting it with nucleus of oculo-motor nerve and opposite colliculus.

Inferior colliculus consists of grey nucleus encapsuled by fibres of lateral lemniscus which end in it.

Cerebral peduncle (*crus cerebri*) consists of *tegmentum* dorsally and *basis* ventrally. Between them is a lamina of coloured matter called **substantia nigra**. On the surface they are marked off from one another laterally by **sulcus lateralis**, medially by **sulcus n. oculomotorii**, along which the roots of oculo-motor nerve emerge.

Tegmentum is joined to its fellow. Between them, near dorsal surface, is the **aquæductus cerebri**, which tunnels mesencephalon, and connects 3rd and 4th ventricles. It is lined with ependyma, and surrounded by tube of grey matter, called *stratum griseum centrale*, which is continuous with grey matter on floor of 4th ventricle and walls of 3rd, and gives origin to oculo-motor and trochlear nerves and mesencephalic motor root of trigeminal. Tegmentum is continuous below with dorsal part of pons. It separates from its fellow above and enters subthalamic region. As they diverge, the medial parts of their upper surfaces take part in formation of posterior region of floor of 3rd ventricle.

Basis Pedunculi (*Crusta*).—Seen on base of brain. **Interpeduncular fossa** separates it from its fellow, from which it diverges upwards, forwards, and laterally, becoming broader as it ascends. Post. cerebral and sup. cerebellar arteries and basilar vein curve backwards, and trochlear nerve forwards, over its surface. Optic tract is in contact with its lateral surface above, where it is continuous with internal capsule. Inferiorly it enters basilar part of pons.

Nucleus ruber (red nucleus) lies in upper part of **tegmentum**,

surrounded by fibres of brachium conjunctivum, many of which end in it. It receives fibres also from cerebral cortex and basal ganglia, and sends fibres to thalamus, and *rubro-spinal tract* (p. 356) to spinal medulla. Roots of 3rd nerve traverse it. **Ganglion interpedunculare**, on ventral surface of tegmentum, in median plane, lies in substantia perforata posterior, at back of interpeduncular fossa. Other contents of tegmentum are dealt with elsewhere:—Medial longitudinal bundle (p. 328), lemnisci (pp. 356, 392), brachia conjunctiva (p. 331), tecto-spinal tract (p. 355), spino-tectal and spino-thalamic tracts (p. 356), fasciculus retroflexus (p. 337).

Basis pedunculi is composed of (1) pyramidal motor fibres, (2) cortico-pontine fibres descending from cerebral cortex to nuclei pontis, and (3) some fibres from medial lemniscus at its medial margin.

Motor fibres occupy medial $\frac{1}{2}$; **fronto-pontine**, medial $\frac{1}{8}$, dorsal to motor fibres; **temporo-** and **occipito-pontine**, lateral $\frac{1}{8}$.

Arteries of mesencephalon come from posterior communicating, anterior chorioidal and posterior cerebral. **Veins** end in vena cerebri magna (Galen).

HYPOTHALAMUS

Optic tract lies on upper end of basis pedunculi, a little below lentiform nucleus, hidden posteriorly by hippocampal gyrus, while anteriorly it lies uncovered between interpeduncular space and vallecula Sylvii. Posteriorly it divides into medial and lateral roots. **Medial root** is connected with medial geniculate body; **lateral root** ends in lateral geniculate body, pulvinar, and, by means of brachium superius, in superior corpora quadrigemina. Anteriorly the fibres of medial root cross in **optic chiasma** to become continuous with fibres of medial root of opposite side, while fibres of lateral root partly run into optic nerve of same side, and partly pass across, in chiasma, to opposite nerve.

Subthalamic tegmental region consists of tegmentum from the point where it separates from its fellow till it reaches thalamus. **Contents**: upper end of red nucleus and its thalamic fibres; fibres of brachia conjunctiva, of brachia quadrigemina, and of lemniscus medialis, substantia nigra, and nucleus hypothalamicus (Luys), which is placed on dorsal or deep surface of basis pedunculi.

Tuber Cinereum.—An elevation of grey matter, anterior to c. mamillaria, continuous, above optic tract and chiasma, with anterior perforated substance and lamina terminalis. It is connected with hypophysis by a stalk, called **infundibulum**, upper hollow end of which forms *recessus infundibuli* of 3rd ventricle.

Hypophysis (pituitary body) lies in fossa on sella turcica of sphenoid, covered by diaphragma sellae. Two lobes, closely applied:—

posterior, connected with infundibulum; **anterior**, developed from roof of pharynx, is the functioning part.

Lamina Terminalis (cinerea), a thin sheet of grey matter, stretches upwards from tuber cinereum, immediately above chiasma, to become continuous with rostrum of corpus callosum, at ant. commissure. Laterally it is continuous with gyrus subcallosus and g. cinguli, and with ant. perforated substance.

Corpora Mamillaria.—Two small, white, pea-like bodies, in front of substantia perforata posterior. Each consists of a nucleus encapsuled in white matter. Column (ant. pillar) of fornix ends in it. **Fasciculus thalamo-mamillaris** (bundle of Vicq d'Azyr) arises in it and passes upwards in thalamus, in ant. tubercle of which it ends. **Fasciculi pedunculo-mamillares** extend posteriorly from it, in floor of 3rd ventricle, to tegmentum of cerebral peduncle.

Pedunculus thalami inferior is a band of fibres derived from thalamus. It lies horizontally on medial side of fasc. thalamo-mamillaris (Vicq d'Azyr); then turns obliquely downwards and forwards, lateral to column (ant. pillar) of fornix; then laterally, at a right angle, as **ansa peduncularis**, below internal capsule and lentiform nucleus, to end in insula and temporal lobe. Above ansa peduncularis is a band, called **ansa lenticularis**, which connects thalamus and lentiform nucleus. Behind and between ansæ is some grey matter mixed with fibres.

THALAMENCEPHALON

Thalamus.— $1\frac{1}{2}$ inches long; ovoid; lies above hypothalamus, its medial surface forming side wall of 3rd ventricle; lateral part of its upper surface appearing in floor of lateral ventricle, medial part covered by tela chorioidea.

Its anterior end, called **anterior tubercle**, lies close to the median plane and bounds the foramen interventriculare (Monro) posteriorly. Posterior end, called **pulvinar**, broad, free, and projecting, diverges from its fellow, overhangs mesencephalon. **Superior surface**, free laterally in floor of lateral ventricle, covered medially by chorioid plexus and by tela chorioidea (velum interpositum), which separates it from body of fornix; stria terminalis (tænia semicircularis) and vena terminalis (vein of corpus striatum) separate its *lateral border* from caudate nucleus; stria medullaris and tænia thalami lie along anterior half of *medial border*. **Medial surface**, in its posterior $\frac{1}{3}$ lies above superior corpus quad.; in anterior $\frac{2}{3}$ forms side wall of 3rd ventricle, and is connected with its fellow by a band of grey matter called **massa intermedia** (middle commissure). **Lateral surface** is applied

to internal capsule. **Inferior surface** is connected with sub-thalamic tegmental region, corpus mamillare, and tuber cinereum.

Structure.—**Medial medullary lamina**, a vertical sheet of fibres, divides it into **lateral** and **medial nuclei**, and splits anteriorly to enclose small **anterior nucleus**. **Stratum zonale** is white layer on upper surface, derived from optic tract and radiation. **Lateral medullary lamina**, an interlacement of fibres passing between its lateral surface and internal capsule.

Connections.—With all parts of central nervous system.

Arteries from posterior communicating, posterior cerebral, lenticulo-optic of middle cerebral. **Veins** end in vena terminalis.

Metathalamus.—**Corpus geniculatum mediale**, an elevation at upper end of lateral groove of mesencephalon, under pulvinar. *Consists of* a nucleus in which fibres of lateral lemniscus end and acoustic radiation arise. *Connected with* its fellow by fibres (commissure of Gudden) which form medial root of optic tract, run forwards in optic tract, cross in chiasma to opposite tract. **Inferior brachium** from inf. corpus quadrigeminum extends towards it and disappears under cover of it.

Corpus geniculatum laterale, an indistinct elevation on lateral part of lower surface of pulvinar. *Consists of* alternate layers of grey and white matter. *Connected with* optic radiation and lateral root of optic tract, and with superior corpus quadrigeminum by means of superior brachium.

Epithalamus — (1) **Commissura posterior** is a slender band of fibres stretching across median plane in posterior wall of 3rd ventricle, dorsal to upper end of aqueductus cerebri, under base of pineal body. Connections not yet definitely made out.

(2) **Corpus Pineale** —A conical body, base directed anteriorly. Lies on groove between superior corpora quadrigemina below splenium of corpus callosum, enveloped in lower layer of tela chorioidea (velum interpositum). Base connected with hollow stalk, divided into *ventral lamina*, which curves downwards in front of post. commissure into matter surrounding aqueduct, and *dorsal lamina*, which splits into 2 bands, called *habenulae*, to become continuous with stria medullaris and tania thalami on each side.

(3) **Trigonum Habenulae**. —A triangular depression between sup. corpus quadrigeminum, stalk of pineal body and pulvinar; grey matter in its floor is **nucleus habenulae**, from which *fasciculus retroflexus* descends through tegmentum to end in ganglion interpedunculare in substantia perforata posterior.

(4) **Stria medullaris**, a band of fibres, under ependymal ridge called *tania thalami*, on medial border of thalamus. Traced backwards

some end in nucleus habenulae of their own side, others cross in dorsal stalk of pineal body (*commissura habenularum*) to opposite nucleus. Traced forwards, they join column (anterior pillar) of fornix, and some are carried backwards in fornix to hippocampus, others descend in column of fornix to cells at base of brain.

VENTRICULUS TERTIUS

Third Ventricle. — A cleft between thalami; anterior wall much deeper than posterior; lined with ependyma. Communicates with 4th ventricle through aqueductus cerebri, and with lateral ventricle, on each side, by **foramen inter-ventriculare** (Monro), a Y-shaped aperture, the stem of which lies in upper and anterior part of 3rd ventricle, while the widely diverging limbs pass, one on each side, between column of fornix in front and anterior end of thalamus behind, into lateral ventricle.

Side wall is formed by thalamus and is connected with opposite side by massa intermedia. *Sulcus hypothalamicus* (Monro) leads backwards, just below thalamus, from for. inter-ventriculare to aqueduct. Below and anterior to this the column of fornix sinks into side wall. **Anterior wall**: free parts of columnæ fornicis; anterior commissure, crossing anterior to them; lamina terminalis below that. **Floor**: from before backwards — optic chiasma, tuber cinereum, corpora mamillaria, substantia perforata posterior, tegmenta. **Posterior wall**: from below upwards — aqueductus cerebri, posterior commissure, base of pineal body. **Roof**: merely ependyma, covered by tela chorioidea of 3rd ventricle (velum interpositum), and fornix above the tela.

Recesses: *recessus opticus*, between lamina terminalis and chiasma; *r. infundibuli*, into upper part of infundibulum; *r. pinealis*, in stalk of pineal body; *r. suprapinealis*, an ependymal protrusion backwards above stalk; *r. triangularis*: bounded inferiorly by ant. commissure, on each side by a column of fornix, anteriorly by septum pellucidum.

CEREBRAL HEMISPHERES

Form largest part of brain. Lie in anterior and middle cranial fossæ and on tentorium cerebelli, which separates them from posterior fossa and its contents. They are directly connected by the corpus callosum and anterior commissure.

Longitudinal fissure separates hemispheres, is occupied by falx cerebri, is complete anteriorly and posteriorly, but is interrupted in middle by corpus callosum.

Grey matter lies on surface of each hemisphere, and *white matter* in interior, but some masses of grey matter, called **basal ganglia**, are lodged in interior and appear on surface only at substantia perforata anterior. Surface everywhere presents convolutions or *gyri*, separated by *sulci*.

Surfaces.—**Lateral** is convex and adapted to cranial vault. **Medial** is flat and perpendicular, and bounds longitudinal fissure. **Inferior**, irregular, divided by stem of fissura lateralis into (1) anterior **orbital area**, which lies on roofs of orbit and nose, and (2) larger **tentorial area**, which is concave, directed downwards and medially, lies on tentorium and floor of middle fossa, and shows a hollow—*impressio petrosa*—where it lies over arcuate eminence of petrous temporal.

Anterior extremity is called **frontal pole**; posterior, **occipital pole**; and anterior end of temporal lobe is called **temporal pole**. Occipital pole shows a groove, better marked on right side, for end of superior sagittal and beginning of transverse (lateral) sinus.

Borders.—**Supero-medial**: between medial and lateral surfaces, from frontal to occipital pole. **Infero-lateral**: from occipital to temporal pole, between lateral and tentorial surfaces; **pre-occipital notch** is a small impression on it, about $1\frac{1}{2}$ in. anterior to occipital pole, and opposite parieto-mastoid suture. **Superciliary**, arches from frontal pole to fissura lateralis, between lateral and orbital surfaces. **Medial orbital**: from frontal pole to chiasma, between medial and orbital surfaces. **Medial occipital**: from occipital pole forwards towards corpus callosum, between medial and tentorial surfaces; lies against straight sinus, in angle between falx cerebri and tentorium.

Hemisphere Outlined on Surface of Head.—**Superciliary border**: a line drawn from root of nose, $\frac{1}{4}$ to $\frac{1}{2}$ inch above supra orbital margin and arched in same degree, as far as zygomatic (ext. angular) process of frontal, and then backwards and upwards to pterion—i.e. $1\frac{1}{4}$ inches behind zygomatic process, $1\frac{1}{2}$ inches above zygoma. **Temporal pole**: a line, convex forwards, from pterion to zygomatic arch, $\frac{1}{4}$ in. behind frontal process of zygomatic (malar). **Infero-lateral border**: a line, slightly convex upwards, drawn along zygoma, above meatus and upper border of mastoid temporal (parieto-mastoid suture), to ext. occipital protuberance. **Supero-**

medial border : from protuberance, $\frac{1}{4}$ inch from median plane on left side, $\frac{1}{2}$ inch on right side, forwards over vertex to root of nose, near median plane.

SULCI AND FISSURES, LOBES AND GYRI OF HEMISPHERE

Surface of hemisphere is divided into lobes — frontal, temporal, parietal, occipital lobes, insula (island of Reil) and gyrus fornicatus or limbic lobe. These are bounded and separated from one another by sulci or fissures, supplemented by imaginary lines.

Boundary sulci : fissura lateralis, f. parieto-occipitalis, f. collateralis ; sulcus circularis (see p. 343), s. centralis, s. cinguli, s. subparietalis.

Fissura cerebri lateralis (Sylvii) consists of stem and 3 branches. **Stem** is the deep cleft on base of brain between frontal and temporal lobes. Middle cerebral artery and deep middle cerebral vein lie in it, and posterior border of roof of orbit projects into it. It begins at “*vallecula Sylvii*” and ends, on lateral surface, at the *Sylvian point*, opposite pterion, by dividing into 3 branches : (1) **Anterior horizontal ramus**, $\frac{3}{4}$ inch long, passes anteriorly into frontal lobe, above superciliary margin. (2) **Anterior ascending ramus**, $\frac{3}{4}$ inch long, passes upwards and anteriorly into frontal lobe. These two may arise by common stem. (3) **Posterior ramus**, more important than stem and the other two rami, runs posteriorly and slightly upwards, towards parieto-occipital fissure, for nearly 3 inches, between temporal lobe below and frontal and parietal lobes above, and then turns sharply up into parietal lobe, its termination being surrounded by supra-marginal gyrus. Middle cerebral artery lies in it. It crosses upper edge of squamous temporal, and is indicated on surface of head by a line drawn from pterion towards lambda, but when the point on a level with and below parietal tuberosity (eminence) is reached it is sharply upturned to end at the eminence.

Sulcus centralis (Rolandi) begins at supero-medial margin, a little posterior to its middle ; extends laterally, downwards and forwards, between frontal and parietal lobes, forming with longitudinal fissure an angle of about 70° (reckoned for convenience as $67\frac{1}{2}^\circ$, *i.e.* $\frac{3}{4}$ of a right angle) ; ends above posterior limb of lateral (Sylvian) fissure, about 1 inch

posterior to Sylvian point. Its course is sinuous, the largest bend curving round arm area. Position on surface is indicated by line drawn from $\frac{1}{2}$ inch behind mid-point between nasion and ext. occipital protuberance, downwards and forwards for 3 or 4 in., over surface of head at an angle of $67\frac{1}{2}^{\circ}$ with median plane (or to a point about 1 inch behind pterion).

Parieto-occipital fissure, on medial surface, about $1\frac{1}{2}$ to 2 inches anterior to occipital pole, between cuneus and præcuneus. Lower end cuts into calcarine fissure. Upper end appears on lateral surface, between parietal and occipital lobes, and is called **lateral parieto-occipital fissure**, round which a gyrus, called *arcus parieto-occipitalis*, is rolled, and whose position is marked by a line drawn laterally from lambda for $\frac{3}{4}$ inch.

Collateral fissure, on tentorial surface, between temporal lobe and gyrus hippocampi (of limbic lobe). Begins near a notch, called **rhinal fissure**, between the temporal pole and uncus. Runs into occipital lobe to end near occipital pole. Sinks so deeply into brain that it produces the *collateral eminence* in floor of inferior horn of lateral ventricle.

Sulcus cinguli (calloso-marginal fissure), on medial surface, between marginal gyrus of frontal lobe and gyrus cinguli (callosal gyrus); begins below anterior end of corpus callosum, runs forwards, then upwards, then backwards, parallel to corpus callosum, and $\frac{1}{2}$ in. away from it, and near its posterior end turns upwards to cut supero-medial margin, just behind sulcus centralis (so that the two are guides to one another).

Subparietal sulcus, a variable sulcus, above and posterior to splenium of corpus callosum, separates præcuneus of parietal lobe from gyrus cinguli.

Sulcus corporis callosi is the slit above corpus callosum.

Lobes are dealt with as they are represented on the various surfaces.

LATERAL SURFACE OF HEMISPHERE

Frontal Lobe.—Bounded *superiorly* by supero-medial margin, *inferiorly* by superciliary margin and part of posterior ramus of fissura lateralis, *posteriorly* by sulcus centralis Rolandi.

Sulci.—**Præcentral**, nearly parallel to s. centralis ; divided into separate *superior* and *inferior* parts ; **superior frontal** is directed anteriorly from superior part ; **inferior frontal**, directed anteriorly from inferior part. Anterior rami of fissura lateralis (Sylvii) run into lower part of lobe.

Gyri.—**G. centralis anterior** (precentral, ascending frontal), between sulcus centralis and s. præcentralis, extends from supero-medial margin to posterior ramus of fissura lateralis ; *the most important of all gyri* ; forms greater part of motor area. Lies under anterior part of parietal bone. Separated by meninges from main branches of anterior division of mid. meningeal art. *Position on surface* : anterior to sulcus centralis Rolandi. **Superior frontal**, above sup. frontal sulcus, and is found on medial surface also. **Middle frontal**, between sup. and inf. frontal sulci. Its middle part lies under frontal tuberosity (eminence), and is said to be occupied by centre for oculo-motor muscles. **Inferior frontal**, below inf. frontal sulcus. Anterior rami of lateral fissure (Sylvius) divide its lower part into three : *pars basilaris*, posteriorly ; *pars triangularis*, between the rami ; *pars orbitalis*, anteriorly, turns round superciliary margin on to orbital surface.

Temporal Lobe.—Bounded *posteriorly* by a line dropped from lateral parieto-occipital fissure ; *superiorly* by posterior ramus of fissura lateralis and a line continuing its main direction backwards ; *inferiorly* by infero-lateral border. Its *anterior* end is temporal pole.

Sulci and Gyri.—**Superior temporal sulcus**, parallel to post. ramus of fissura lateralis and turns up into parietal lobe. **Middle temporal sulcus**, near infero-lateral margin, usually interrupted, also turns up into parietal lobe. These two sulci divide lateral surface into *superior*, *middle*, and *inferior temporal gyri*, the last of which turns round infero-lateral margin and appears on tentorial surface. Posterior branch of mid. meningeal artery runs parallel with middle gyrus or sulcus, separated from it by meninges. Upper surface of temporal lobe is concealed and presents some *transverse sulci and gyri*.

Parietal Lobe.—Bounded *superiorly* by supero-medial margin ; *anteriorly* by s. centralis Rolandi, *posteriorly* by line drawn from lateral parieto-occipital fissure towards pre-occipital notch ; *inferiorly* by posterior part of post. ramus of lateral fissure and line continuing its main direction backwards.

Sulci. — **Interparietal** consists of: (1) *Post-central sulcus*, behind s. centralis, sometimes divided into upper and lower parts. (2) *Ramus horizontalis* passes backwards from post-central sulcus into occipital lobe, where it is called *r. occipitalis* and divides into two widely diverging limbs which form *sulcus occipitalis transversus*. Ramus posterior of lateral fissure (Sylvius) and the upper and middle temporal sulci run into lower part of lobe.

Gyri. — **G. centralis posterior** (post-central, ascending parietal), between s. centralis and post-central sulcus. **Superior parietal lobule** between ramus horizontalis and supero-medial margin. **Arcus parieto-occipitalis**, rolled round lateral parieto-occipital fissure, is limited laterally by ramus horizontalis and r. occipitalis at their junction, and belongs partly to occipital lobe. **Inferior parietal lobule**, below r. horizontalis, is divided into three: (1) *Supra-marginal gyrus* surrounds end of ramus posterior of fissura lateralis, lies under parietal eminence. 2) *Angular gyrus* surrounds end of sup. temporal sulcus. 3) *Post-parietal gyrus* surrounds end of middle temporal sulcus; lies immediately lateral to arcus parieto-occipitalis, 1 inch distant from lambda.

Occipital Lobe. — Bounded *anteriorly* by line drawn from parieto-occipital fissure to pre-occipital notch; *superiorly* by supero-medial; *inferiorly* by infero-lateral margin.

Sulci and gyri are very inconstant.

Blood supply of lateral surface of hemisphere. Ant. cerebral supplies strip, $\frac{1}{2}$ in. broad, along supero-medial margin, as far back as parieto-occipital fissure. Posterior cerebral supplies inf. temporal gyrus and greater part of occipital lobe; middle cerebral supplies remainder. Veins end in sagittal, cavernous, transverse (lateral), superior petrosal sinuses and deep middle cerebral vein.

Insula (Island of Reil). — A pyramidal elevation lying concealed at bottom of lateral fissure (Sylvius). **Sulcus circularis** circumscribes its base and is divided into anterior, superior, and posterior parts. Its surface presents two **gyri longi** posteriorly, and several **gyri breves** anteriorly. Middle cerebral art. divides into branches on its surface. Claustrum, external capsule and lentiform nucleus are medial to it, in that order from the surface. Parts concealing it are lips of stem and branches of lateral fissure (of Sylvius), and are called **opercula**: (1) **Temporal operculum**, postero-inferiorly, between stem and post. ramus. 2) **Fronto-parietal**, superiorly,

between posterior and ant. ascending rami. (3) **Frontal**, antero-superiorly, between anterior rami (synonymous with *pars triangularis*). (4) **Orbital**, antero-inferiorly, between stem and ant. horizontal ramus of lateral fissure (corresponds to posterior part of *pars orbitalis*). (This description of opercula does not conform to B.N.A. terminology, which is difficult to apply.)

Blood Supply.—Middle cerebral art. Deep middle cerebral vein.

ORBITAL SURFACE OF HEMISPHERE

Belongs to frontal lobe. *Bounded anteriorly and laterally* by superciliary margin, *medially* by medial orbital margin, *posteriorly* by vallecule Sylvii and stem of lateral fissure.

Sulci.—**Olfactory**, near and parallel to medial orbital margin, occupied by olfactory bulb and tract ; **sulci orbitales**, irregular, usually form H-shaped figure.

Gyri.—**G. rectus**, medial to olfactory sulcus ; **medial orbital**, between olfactory sulcus and H-shaped sulcus ; **Anterior and posterior orbital**, separated by cross piece of H. Part lateral to H is inf. frontal gyrus turned round margin.

Blood Supply.—Ant. cerebral art. supplies gyrus rectus and medial orbital gyrus ; middle cerebral supplies remainder. Veins end in middle cerebral and anterior cerebral veins.

MEDIAL AND TENTORIAL SURFACES OF HEMISPHERE

Gyri are arranged in three concentric circles.

Outer Circle.—**Marginal gyrus** includes that part of superior frontal gyrus which appears on medial surface. Lies between sulcus cinguli (calloso-marginal) and margin of hemisphere. Its posterior end, partially cut off, is called **paracentral lobule** ; upper end of sulcus centralis Rolandi cuts into it, and part of paracentral lobule surrounding it is the motor area of opposite leg.

Præcuneus (quadrate lobule) belongs to parietal lobe. Bounded *anteriorly* by upturned end of sulcus cinguli, *superiorly* by supero-medial margin, *posteriorly* by parieto-occipital fissure, *inferiorly* by sub-parietal sulcus.

Calcarine fissure begins at occipital pole and ends below splenium of corpus callosum, from which it is separated by isthmus of gyrus fornicatus. It is convex upwards, and is

joined at maximum convexity by parieto-occipital fissure. Anterior part is so deep that it produces elevation, called *calcar avis*, in post. horn of ventricle. **Cuneus** is the gyrus on medial surface of occipital lobe, between parieto-occipital and calcarine fissures. **Gyrus lingualis**, partly on medial surface, mainly on tentorial surface of occipital lobe, lies between calcarine and collateral fissures, and is continuous anteriorly with gyrus hippocampi.

Inferior temporal sulcus (occipito-temporal), usually interrupted, lies between collateral fissure and infero-lateral margin. **Gyrus fusiformis** (occipito-temporal) is bounded by collateral fissure and inf. temporal sulcus, which separates it from that part of inf. temporal gyrus which turns round infero-lateral margin on to tentorial surface.

Intermediate Circle—**Gyrus fornicatus** (Limbic lobe). Consists of 3 parts: (1) **Gyrus cinguli** (callosal gyrus) begins near substantia perforata anterior, below corpus callosum; arches round ant. end of corpus callosum and runs backwards between sulcus cinguli (calloso-marginal) and sulcus corporis callosi; ends at splenium of corpus callosum by joining isthmus. (2) **Isthmus gyri fornicati** is the narrow strip, between corpus callosum and calcarine fissure, which connects gyrus cinguli and g. hippocampi. (3) **Gyrus hippocampi** is the most medial and highest convolution on tentorial surface; separated from mesencephalon by gap in which posterior cerebral artery and basilar vein lie, and from gyrus fusiformis by collateral fissure. Posterior end is continuous medially with isthmus, laterally with g. lingualis. Its enlarged anterior end, called the **uncus** (because its medial part is bent back so as to form a hook), is separated from temporal pole by the rhinal fissure; overlaps basis pedunculi and hides optic tract; forms postero-lateral boundary to *vallecula Sylvii* and substantia perforata anterior.

Inner Circle.—Rudimentary. **Supra-callosal gyrus**, a very thin transparent layer of grey matter spread over upper surface of corpus callosum and continuous with g. cinguli at bottom of sulcus corporis callosi; contains, near median plane on each side, two slender longitudinal strands of fibres, called *striae longitudinales*, *medialis* and *lateralis*, *stria lateralis* lying under cover of gyrus cinguli. **Gyrus subcallosus**, a narrow strip of grey matter on lower surface of anterior end of corpus callosum, close to medial surface of hemisphere, continuous above with supra-callosal; ends below by dividing into two parts of which one joins medial root of olfactory tract, the other runs through substantia perforata anterior to anterior end of temporal lobe. **Fasciola cinerea** is the small strip continued from supra-callosal gyrus, round splenium of corpus

callosum, to join fascia dentata. **Fascia dentata** (dentate gyrus) (seen best in specimen showing posterior horn and floor of inferior (descending) horn of ventricle detached from rest of brain) is a curled lamina of grey matter, largely contained within hippocampus, but protruding medially as a notched margin, between fimbria hippocampi and upper surface of gyrus hippocampi. Posteriorly it is continuous with fasciola cinerea. Anteriorly it disappears into cleft of uncus; emerges again as a delicate band, called *frenulum of Giacomini*, which turns medially over recurved part of uncus and is lost on its surface. **Fissura hippocampi** is the slit between fascia dentata and upper surface of gyrus hippocampi. Posteriorly it is continuous with sulcus corporis callosi; anteriorly it runs into cleft of uncus.

Blood Supply of Medial and Tentorial Surfaces.—Anterior cerebral artery supplies medial surface almost as far back as parieto-occipital fissure. Middle cerebral supplies temporal pole. Posterior cerebral supplies the rest. Veins end in sagittal, transverse, superior petrosal and cavernous sinuses, anterior cerebral and basilar veins.

RHINENCEPHALON

Olfactory Lobe.—**Olfactory bulb**, $\frac{3}{4}$ inch long, oval, lies in olfactory sulcus of brain, and on lamina cribrosa of ethmoid; olfactory nerves, about 20 in number, from olfactory mucous membrane, enter its inferior surface. **Olfactory tract**, a prismatic band continued posteriorly from bulb, lies in olfactory sulcus and on upper surface of ant. part of body of sphenoid; divides posteriorly into three roots or striæ; *stria medialis* curves medially, behind gyrus rectus, above optic nerve, and ends partly in gyrus cinguli (callosal) and partly by joining gyrus subcallosus. *Stria lateralis* runs postero-laterally along lateral part of anterior perforated substance; some of its fibres end in it, others curve medially to end in uncus. *Stria intermedia*, not always seen, runs over **trigonum olfactorium**—a triangular elevation in front of ant. perforated substance, between medial and lateral striæ—and ends in perforated substance. **Area par-olfactoria** (Broca) is posterior end of gyrus rectus and a small area on medial surface, separated by *anterior* and *posterior par-olfactory sulci* from gyrus cinguli and g. subcallosus, respectively. It is continuous with olfactory trigone and lies anterior to medial stria.

Substantia Perforata Anterior (Anterior Perforated Spot). Fornix floor of vallecula Sylvii. Bounded by striæ (roots) of olfactory tract, optic tract and nerve; overlapped by uncus postero-laterally. *Continuous medially*, above optic tract and nerve, with tuber cinereum and lamina terminalis; *laterally* with **limen insulæ**, i.e. the medial side of apex of insula, where circular sulcus is defective; *above* with caudate, lentiform and amygdaloid nuclei and claustrum. Temporal part of g. subcallosus runs through its superficial part posteriorly. Anterior

commissure crosses on deep part of its substance; ansa peduncularis and ansa lenticularis turn laterally between it and lower end of internal capsule. Fibres of olfactory tract, stria terminalis (tenia semicircularis) and cingulum are connected with its cells. Central branches of middle cerebral artery perforate it.

Rhinencephalon includes also subcallosal and supra-callosal gyri, dentate fascia, septum pellucidum, fornix, corpus mamillare, fasciculus thalamo-mamillaris, hippocampus, gyrus fornicatus, cingulum, and a minute part of anterior commissure. These are dealt with in the regions they occupy.

CORPUS CALLOSUM AND COMMISSURA ANTERIOR

Corpus Callosum is the chief commissure of the hemispheres. Its fibres radiate to all parts of cortex, except lower and anterior parts of temporal lobe, which are commissured by anterior commissure. It forms floor of longitudinal fissure, and unites medial surfaces of hemispheres in nearly half their length, but is nearer anterior than posterior end of brain. It is concave downwards on sagittal section, concave upwards on frontal coronal section. Upper surface is covered by gyrus supra-callosus and strie longitudinales, and is in relation, on each side, to anterior cerebral vessels, gyrus cinguli (callosal) and cingulum. Posterior end is thick, owing to reduplication downwards and forwards, and is called **splenium**; it is touched by falx cerebri and overhangs superior corp. quad., pineal body, base of tela chorioidea (velum interpositum) and vena cerebri magna (Galenii). Anterior end, thickened and bent downwards and backwards, is called **genu**, lower part of which is prolonged, as thin lamina called **rostrum**, downwards and backwards to join lamina terminalis at anterior commissure. Intermediate part is called **truncus corporis callosi** (body of c. callosum). Deep surface of trunk and genu, covered laterally with ependyma, forms roof and anterior wall of body and anterior horn of lateral ventricle; in median plane septum pellucidum intervenes between them (*i.e.* trunk and genu) and fornix, but fornix is adherent to posterior end of trunk.

Forceps minor is the name given to arch formed by fibres of genu, as they curve forwards into frontal lobes. Wider arch, formed by fibres of splenium passing into occipital lobes, is called **forceps major**. It consists of upper and lower parts, above and below bottom of calcarine fissure; upper part is that seen in ordinary dissection, and it produces an elevation,

called the *bulb*, on medial wall of post. horn of ventricle, above calcar avis. Fibres of main part of trunk intersect with corona radiata above corpus striatum, as they pass to cortex; but some fibres of splenium and of posterior part of trunk pass on as an uninterrupted sheet called *tapetum*, which forms roof and lateral wall of posterior horn and lateral wall of inferior horn of ventricle, and lies between endyma and the optic radiation.

Anterior commissure connects inferior and anterior parts of temporal lobes of opposite sides. **Median part** is free in ant. wall of 3rd ventricle, in front of columns of fornix, below recessus triangularis and above r. opticus. It is covered with endyma of ventricle and is connected with septum pellucidum, lamina terminalis, and rostrum of corpus callosum. **Lateral part** is in substance of hemisphere. It passes laterally and backwards, as a round compact cord, below caudate nucleus, internal capsule and lentiform nucleus, the lower surface of which it grooves deeply, and sinks into white substance of temporal lobe, where it spreads out like a fan. Anterior perforated substance, amygdaloid nucleus and fibres of temporal radiation are beneath it. As it crosses perforated substance it sends forwards, through it, an *olfactory bundle* to join lateral root of olfactory tract. Fibres of this bundle connect olfactory bulb with opposite temporal lobe and olfactory bulb.

FORNIX AND SEPTUM PELLUCIDUM

Fornix.—Highly arched. Consists of body, 2 crura, 2 columns. Composed mainly of longitudinal fibres connecting parts on same side of median plane, but also of commissural fibres, connecting the hippocampi of opposite sides.

Corpus Fornicis.—Triangular, apex anteriorly. Consists of lateral halves fused along median plane. The halves separate anteriorly to form the columns, posteriorly to form crura. *Superior surface* in median plane is adherent to corpus callosum posteriorly, and is connected with it by means of septum pellucidum anteriorly. Laterally, the body projects into lateral ventricle on each side, and is covered with endyma, and choroid plexus lies along its *free margin*. *Inferior surface* rests on tela chorioidea (velum interpositum), which separates it from thalami and endymal roof of 3rd ventricle.

Crus Fornicis (Posterior Pillar).—Thin, flat, is adherent to corpus callosum. Diverges from its fellow; turns round post. end of thalamus; enters inferior horn of ventricle, and its fibres partly spread out to form white covering (*alveus*) of hippocampus, and partly run along concave medial margin of hippocampus, forming a pro-

minent edge, called **fimbria**, which ends in tip of uncus, and is separated from underlying dentate fascia by **fimbrio-dentate fissure**.

Columna Fornicis (Anterior Pillar).—Rounded; arches downwards, anterior to foramen interventriculare (Monro), posterior to ant. commissure; diverges from its fellow; sinks into side wall of 3rd ventricle; descends to corpus mamillare, in which it ends. Around nucleus of c. mamillare the fibres of columna and of fasc. thalamo-mamillaris (p. 336) make fig. of 8 twist. Some fibres, called **olfactory bundle**, descend in front of ant. commissure, through septum pellucidum, join gyrus subcallosus, and end in medial root of olfactory tract and in uncus. Some turn backwards as stria medullaris under tenia thalami (p. 337). Stria terminalis joins columna.

Fibres of fornix arise in hippocampus, dentate fascia and uncus. Most pass along crus and body into column, but many cross and run in opposite half of body and crus to opposite hippocampus, forming **commissura hippocampi**.

Septum pellucidum is an antero-posterior vertical septum between bodies and anterior horns of the two lateral ventricles; attached by its edges to corpus callosum superiorly and anteriorly, to fornix inferiorly, occupying triangular interval between them. Antero-inferior angle, between columns of fornix and rostrum, ends in subcallosal gyri below. Consists of two laminae enclosing a cleft, called **cavum septi pellucidi** (fifth ventricle), shut in on all sides. Each lamina consists of a medial grey layer and a lateral white layer, covered with ependyma of lateral ventricle.

VENTRICULUS LATERALIS

Lateral ventricle is the cavity of hemisphere. Lined with ependyma; communicates with 3rd ventricle and opposite lateral ventricle through foramen interventriculare (Monro). Consists of central part or body, and anterior, posterior and inferior horns or cornua.

Anterior horn is the part anterior to for. interventriculare. *Roof*: trunk of corpus callosum. *Anterior wall*: genu of c. callosum. *Medial wall*: septum pellucidum. *Floor*: sloping, convex head of caudate nucleus. Roof and floor may meet laterally, or there may be an interval between them (*lateral wall*), where ependyma is separated from corona radiata by occipito-frontal bundle (p. 354).

Pars centralis or **body** extends from for. interventriculare to splenium. *Roof*: trunk of c. callosum. *Medial wall*: septum pellucidum. *Floor*: caudate nucleus, stria terminalis, tenia semicircularis, vena terminalis v. of

corpus striatum), thalamus, chorioid plexus, body of fornix, in that order from lateral to medial side and from before backwards. Floor and roof usually meet laterally, but condition may be as in ant. horn.

Posterior horn passes from splenium backwards and medially into occipital lobe, tapering to a point. *Roof* and *lateral wall*: tapetum of c. callosum. *Infero-medial wall*: bulbus cornu posterioris above, produced by forceps major; calcar avis below, produced by calcarine fissure.

Inferior horn curves posteriorly and laterally behind optic thalamus, then downwards and anteriorly into temporal lobe, and, lastly, medially into region of uncus. *Roof*: tail of caudate nucleus, stria terminalis on medial side of tail; amygdaloid tubercle at anterior end. *Lateral wall*: tapetum of c. callosum. *Floor*: eminentia collateralis laterally, produced by collateral fissure, may be divided into anterior and posterior parts, may be absent; hippocampus medially, concealed by chorioid plexus; fimbria, attached to medial margin of hippocampus. *Medial wall*: ependyma only, and it is invaginated by chorioid plexus.

Trigonum collaterale (ventriculi) is floor of space lateral to point of divergence of posterior and inferior horns. Posterior part of collateral eminence appears in it.

Stria terminalis (tænia semicircularis), a slender band of fibres, begins in amygdaloid nucleus, runs posteriorly in roof of inferior horn, medial to tail of caudate nucleus; turns up into body of ventricle, lateral to posterior end of thalamus; runs anteriorly between thalamus and caudate nucleus, joins column of fornix; and its fibres, passing in front of and behind anterior commissure, end in anterior perforated substance. Its deep surface lies on internal capsule; it is covered by ependyma and vena terminalis.

Hippocampus (major) is an elongated, curved elevation in floor of inferior horn. Posterior end, at corpus callosum, is narrow. Anterior end, at extremity of horn, below amygdaloid tubercle, is enlarged and notched and is called **pes hippocampi**. Elevations between notches are called *digitations*. Surface layer, called **alveus**, consists of white fibres (p. 348). Fimbria is attached along its medial concave side.

Chorioidal fissure extends from for. interventriculare to ant. end of inf. horn. *Upper part* lies between edge of body of fornix and thalamus; *intermediate part* is between crus fornicis and post. end of thalamus; *lower part* is between fimbria and stria terminalis (tænia semicircularis). Through it the chorioid plexus protrudes into body and inferior horn of ventricle, invaginating ependyma before it.

Transverse fissure is the horse-shoe shaped cleft through which tela chorioidea of 3rd ventricle (velum interpositum) and the choroid plexuses are introduced into interior. *Lateral* or lower parts are the choroidal fissures; *intermediate* or upper part is bounded superiorly by splenium of c. callosum and body of fornix, inferiorly by thalami and ependymal roof of 3rd ventricle.

BASAL GANGLIA

Caudate, lentiform and amygdaloid nuclei, and claustrum.

Caudate Nucleus. — An elongated body of grey matter, highly arched, so that it is cut in two places by both horizontal and frontal (coronal) sections. Enlarged convex part in floor of anterior horn is called the **head**; narrowing portion in body of ventricle and in inferior horn is called the **tail**. *Superficial surface* is covered with ependyma. *Deep surface* of head lies upon internal capsule, that of tail upon foot piece of corona radiata. Laminae of grey matter pass through these to connect it with lentiform nucleus. These laminae become thicker and more numerous towards head of nucleus until the two nuclei are fused antero-interiorly. Fused lower part lies imbedded in white substance of gyrus rectus and post. orbital gyrus, and behind that is continuous with anterior perforated substance. Anterior commissure passes laterally below head. In body of ventricle, medial edge of caudate nucleus is separated from thalamus by stria and vena terminalis; lateral edge is separated from foot-piece of corona radiata by occipito-frontal bundle. In roof of inferior horn it is in contact by its medial edge with stria terminalis, by its lateral edge with free margin of tapetum; and its tail ends in amygdaloid nucleus.

Lentiform Nucleus **Lenticular Nucleus.** Imbedded in white substance of hemisphere. $1\frac{1}{2}$ inches long, 1 inch in height, $\frac{3}{4}$ inch in maximum width. *Lateral surface*, convex, smooth, grooved inferiorly by lenticulo-striate and optic arteries before they enter its substance; covered by external capsule, beyond which are claustrum and white and grey matter of insula. *Medial surface*—highly convex or angled; applied to internal capsule, which separates it from thalamus, head of caudate nucleus and stria terminalis; maximum convexity or angle lies against genu, opposite stria terminalis; continuous with head of caudate nucleus antero inferiorly, and connected with both head and tail by grey laminae which pass through int. capsule and foot-piece of corona radiata. *Inferior surface*, nearly flat, triangular or bi-convex in outline, does not extend so far as anterior end; deep groove, which lodges ant. commissure, runs postero-laterally from antero-medial margin, and is restricted to putamen. Optic tract is a little below posterior part of medial margin. Anterior part of surface is continuous with ant. perforated

substance, and, behind that, it lies above roof of inferior horn, being partly continuous with amygdaloid nucleus and partly separated from it and from stria terminalis and tail of caudate nucleus by ant. commissure, acoustic radiation, and temporo-pontine tract. *Superior margin*, convex, lies just below superior longitudinal fasciculus. A horizontal or a frontal section of lentiform nucleus shows large **putamen** laterally, separated by **lateral medullary lamina** from pale, triangular **globus pallidus**, which forms the medial and smaller part of the nucleus and is divided into 2 nuclei by **medial medullary lamina**. Putamen alone is connected with caudate nucleus.

Lentiform nucleus does not extend so far forwards or upwards as caudate, nor so far backwards as thalamus. Lentiform and caudate nuclei are together called **corpus striatum**, because in frontal (coronal) sections through their anterior ends the laminae connecting them give internal capsule a cross-barred appearance. They are connected by fibres with thalamus, cortex, and tegmentum. They are supplied by middle and anterior cerebral and ant. chorioid arteries. Lenticulo-striate and -optic branches of middle cerebral groove lower part of lateral surface of lentiform nucleus, then sink into it, traverse it and internal capsule to reach caudate nucleus and thalamus. Largest of lenticulo-striate arteries is "the artery of cerebral hæmorrhage."

Clastrum.—A thin plate of grey matter consisting of detached deepest layer of cortex of insula. Lies lateral to lentiform nucleus, between external capsule and white substance of insula. Thick inferior margin is continuous with anterior perforated substance.

Amygdaloid Nucleus.—Lies in anterior part of roof of inferior horn of ventricle. Is continuous with grey matter of putamen of lentiform nucleus, anterior perforated substance, and uncus. Tail of caudate nucleus ends in it, and stria terminalis begins in it.

CAPSULA INTERNA

Internal capsule is a broad, thick, fan-shaped band in which the fibres of projection system are gathered together. Narrow *lower end* is continuous with basis pedunculi (crusta), under cover of optic tract. Broad *upper end* is continuous with corona radiata at anterior, posterior, and superior margins of lentiform nucleus. *Antero-inferior border* lies on ansa lenticularis, ant. commissure, and line of fusion of lentiform nucleus and head of caudate nucleus. *Posterior border* is very short and thick, and is covered by stria terminalis, as it turns from body of lateral ventricle

into inferior horn. Capsule is bent on itself so that *lateral surface* is concave from before backwards. It looks laterally and downwards and is covered by lentiform nucleus. *Medial surface* is irregular, convex from before backwards, and looks medially and upwards. Head of caudate nucleus lies on it anteriorly, thalamus posteriorly, stria terminalis between them, at the maximum convexity or angle. Portion between lentiform nucleus and head of caudate nucleus, when seen in horizontal section, is called **anterior limb** (B.N.A. pars frontalis) (ant. $\frac{1}{3}$), and is interrupted by laminae connecting the nuclei; portion between lentiform nucleus and stria terminalis is the **genu**; and large portion lateral to thalamus is **posterior limb** (B.N.A. pars occipitalis) (post. $\frac{2}{3}$), and it is divided into *lenticular part*, between lentiform nucleus and thalamus, and *retro-lenticular part*, behind and below posterior end of lentiform nucleus.

Anterior limb contains: (1) Fibres passing to and fro between thalamus and corpus striatum and cortex. (2) Fronto-pontine fibres descending from frontal cortex through corona radiata, int. capsule and medial part of basis pedunculi to nuclei pontis. **Genu and lenticular part** contain: (1) Fibres to and fro between cortex and thalamus; (2) cortico-pontine fibres from motor area to nuclei pontis, and motor fibres for the head and neck, upper limb, trunk, lower limb, in that order from before backwards. **Retro-lenticular part** contains: (1) Optic radiation; (2) occipito-pontine and (3) temporo-pontine tracts, from cortex to nuclei pontis, passing through lateral part of basis pedunculi; (4) acoustic radiation; (5) temporo-thalamic tract, which connects lateral geniculate body with temporal cortex. (3), (4), (5) pass to temporal lobe above roof of inferior horn of ventricle, below lentiform nucleus.

Arterial supply is from anterior and middle cerebral, ant. choroid and posterior communicating arteries.

Capsula Externa and Stria of Gennari

External Capsule is a thin white layer between lentiform nucleus and claustrum, merging at its periphery into white substance of hemisphere. Consists mainly of association fibres, with some fibres of anterior commissure and of ansa lenticularis.

Stria of Gennari is a thin white layer in substance of grey cortex of occipital lobe, seen when fresh brain is sectioned. Associated with visual area; best marked near calcarine fissure.

Lymph of brain travels along lymph paths in walls of blood-vessels and is conveyed away by the meningeal lymph

vessels which pass through foramen magnum, canalis hypoglossi, carotid canal, and jugular foramen, to end in upper deep cervical glands.

WHITE SUBSTANCE OF HEMISPHERE

Is made up of projection fibres, commissural fibres, and association fibres, mingled together.

Commissural fibres are those of corpus callosum and anterior commissure. **Projection fibres** form the *corona radiata*, which consists of the fibres descending from cerebral cortex to parts beneath, and ascending from them to cortex. It is continuous with internal capsule. As it approaches internal capsule its fibres are collected together between superior longitudinal fasciculus laterally and tail of caudate nucleus and occipito-frontal fasciculus medially. This part is the *foot-piece* of *corona radiata*. Immediately above the foot-piece its fibres, except those continuous with retro-lenticular part of capsule, intersect with fibres of corpus callosum.

Association fibres connect different areas of cortex of same hemispheres. *Short association fibres* arch round bottoms of cerebral sulci and connect neighbouring gyri. *Long association fibres* connect gyri further apart, and are collected into bundles which, throughout their whole course, send fibres into overlying gyri and receive others from them: (1) **Fasciculus longitudinalis superior** lies on lateral side of foot-piece of *corona radiata*, in base of fronto-parietal operculum. Begins in frontal lobe, arches backwards above lentiform nucleus, and at posterior end of lateral fissure (of Sylvius) it sends some fibres back into occipital lobe, while most turn downwards and forwards into temporal lobe. (2) **F. longitudinalis inferior**, broad and flat, lies on lateral side of optic and temporal radiations; extends from occipital to temporal pole. (3) **F. uncinatus** arches round stem of lateral fissure (Sylvius), and connects frontal pole and orbital gyri with anterior part of temporal lobe. (4) **Cingulum** lies in gyrus fornicatus. Begins at ant. perforated substance, arches round genu and lies on trunk of corpus callosum in lower part of gyrus cinguli (callosal); bends round splenium, passes through isthmus into hippocampal gyrus, and ends at uncus and temporal pole. (5) **F. occipito-frontalis** lies below corpus callosum, between foot-piece of *corona radiata* and caudate nucleus. Begins in frontal lobe, and at splenium it joins tapetum and radiates into occipital and temporal lobes.

PROJECTION TRACTS IN BRAIN AND SPINAL MEDULLA

Motor.—Pyramidal motor fibres arise in large pyramidal cells (Betz's) in motor area; pass through *corona radiata*, descend

through genu and lenticular part of post. limb of *int. capsule*, through medial $\frac{1}{2}$ of *basis pedunculi* (see Mesencephalon), through *basilar part of pons*, where they are broken up into **pyramidal bundles**, which join again and enter *medulla oblongata* as **pyramid**. 70 to 90 per cent decussate and pass down *lateral funiculus* of opposite half of *spinal medulla* as **lateral pyramidal tract**, and end round cells at base of *posterior column* (horn). From these cells new fibres proceed forwards, and end round cells of *anterior column* from which **motor roots of spinal nerves** arise. A small number of remaining 10 to 30 per cent join the tract which has crossed from opposite side, while the majority descend in *anterior funiculus* of same side as **anterior pyramidal tract**. These cross, at different levels, to opposite side, through white commissure of spinal medulla, and end like those of lateral tract. They have all crossed at level of mid-thoracic region. This tract is found only in man and anthropoid apes.

In *internal capsule* the fibres for motor cerebral nerve nuclei lie in genu, those for upper limb, trunk and lower limb lie in post. limb, in that order from before backwards. In *basis pedunculi* (crusta) fibres of cerebral nerves are most medial, and arm, trunk, and lower limb are in that order medio-laterally; fibres are sent across median plane to motor nuclei of opposite 3rd, 4th, 5th nerves; fibres run backwards also to superior corpus quadrigeminum, to end round cells which give origin to tecto-spinal tract. In upper part of *pons*, fibres are sent across to nuclei of opposite 5th, 6th, 7th nerves, and, in *medulla oblongata*, to nuclei of opposite 6th, 10th, 11th, 12th nerves.

Tecto-spinal tract arises in sup. corp. quad.; decussates in mesencephalon, ventral to medial longitudinal bundles; descends opposite side of tegmentum, pons, and medulla oblongata, ventral to and partly mixed with longitudinal bundle, to enter anterior funiculus of spinal medulla, where it ends in anterior column (horn), extending all the way down.

Sensory.—Sensory fibres arise in cells of peripheral ganglia of cerebral nerves and ganglia of posterior roots of spinal nerves; one branch of each cell passes to periphery, the other passes to central nervous system and divides into ascending and descending branches. Central branches of *spinal ganglia* form **posterior nerve roots**, which enter spinal medulla along posterior lateral sulcus. Their **descending branches** form comma tract and end in posterior column (horn). Their **ascending branches** form fasciculus cuneatus, f. gracilis and postero-lateralis (Lissauer). Most of them end in **grey matter of spinal medulla**, but a small proportion ends in nuclei f. cuneati and gracilis, on dorsal surface of medulla oblongata. **Internal arcuate fibres** arise from these nuclei, arch ventrally and medially, and decussate ventral to grey matter around central canal dorsal to and above decussation of pyramids. Having decussated, some fibres proceed onwards as external arcuate fibres to

ventral surface of medulla oblongata, and join restiform body (p. 326), but most of them turn sharply upwards and form **medial lemniscus**—a broad flat band near median raphe of medulla oblongata, with tecto-spinal tract and medial longitudinal bundle on its dorsal edge, pyramid on ventral edge. As it enters pons it is twisted so that its surfaces are dorsal and ventral, and it lies between dorsal and basilar parts of pons, some fibres of corpus trapezoideum intersecting it. Some of its medial fibres join basis pedunculi (crusta), but bulk of it enters tegmentum, dorsal to substantia nigra, and at first ventral to brachium conjunctivum (sup. cerebellar peduncle), then lateral to it, and finally dorso-lateral to it and to red nucleus. It sends some fibres to superior corpus quadrigeminum, but most of it runs on through subthalamie region to **thalamus**, where its fibres end. (A few may pass directly to cortex through internal capsule and corona radiata.) In medulla oblongata and pons it is joined by fibres from sensory nuclei of cerebral nerves of opposite side.

Spino-thalamic tract consists of fibres which arise from cells of post. column of spinal medulla, cross in white commissure, turn upwards, partly in antero-lateral superficial tract, and partly scattered through lateral funiculus; ascend through formatio reticularis grisea of medulla oblongata, dorsal part of pons, tegmentum, and subthalamie region, to end in **thalamus**.

New fibres arise from cells in thalamus round which fibres of lemniscus and spino-thalamic tract end, and they proceed by way of internal capsule and corona radiata to sensory areas of cortex.

Other Tracts conveying Impulses from and to Cells of Spinal Medulla.—**Fasciculus cerebello-spinalis** (Direct cerebellar, Flechsig) arises from base of posterior column (horn) of spinal medulla, beginning at upper lumbar region; ascends at surface of lateral funiculus of spinal medulla and medulla oblongata, in front of posterior nerve-roots; turns obliquely backwards over postero-lateral sulcus of medulla oblongata and tractus spinalis (spinal root of V.), and joins restiform body, by which it is carried into cerebellum, to end in superior vermis, on both sides of median plane.

Antero-lateral superficial fasciculus (Gowers') arises from posterior column, beginning in lumbar region, ascends at surface of lateral funiculus, in front of f. cerebello-spinalis, and encroaching on anterior funiculus. In medulla oblongata most of it sinks under cover of olive, but some fibres run up along posterior edge. They all pass up dorsal division of pons, and at its upper border turn backwards on lateral surface of brachium conjunctivum (sup. cer. ped.), and are carried by it and anterior medullary velum into cerebellum, to end in its cortex. Some of its fibres pass to opposite half of cerebellum in brachium pontis; others run up to sup. corpus quad. (spino-tectal fibres); and spino-thalamic fibres go to thalamus.

Rubro-spinal tract arises in red nucleus, crosses median plane, descends through tegmentum, dorsal part of pons, substantia

reticularis grisea of medulla oblongata, lateral funiculus of medulla spinalis, ventral to lateral pyramidal tract, and its fibres end round cells behind base of anterior column (horn).

Ponto-spinal Tract.—Scattered fibres arising in nuclei pontis and dorsal part of pons, descending through reticular substance of medulla oblongata and lateral funiculus of spinal medulla to end round cells of anterior column. *Vestibulo-spinal tract*, see p. 392.

MENINGES OF BRAIN AND SPINAL MEDULLA

Brain and spinal medulla are enveloped in three membranes, named, from without inwards, dura mater, arachnoid, and pia mater.

Dura Mater Encephali.—Firm and dense. Consists of two layers which are adherent, except along certain lines where they separate to enclose venous sinuses. **Outer layer** is the periosteum of the cerebral surfaces of cranial bones, to which it is firmly adherent over base, but less firmly adherent over vault, except along sutures, where it is continuous with sutural ligaments. It is continuous with external periosteum of skull through the foramina. **Inner layer** is smooth. It is prolonged as sheaths to nerves as they leave skull. It is firmly adherent to outer layer at foramen magnum and is continuous there with spinal dura. It projects four processes into cranial cavity, each consisting of two adherent laminae:—

(1) **Falx cerebri**, projects downwards into longitudinal fissure of cerebrum. Sickle-shaped; narrow anteriorly, broad posteriorly at its base. *Convex margin* is attached to crista galli, frontal crest, lips of sagittal sulcus on frontal, parietal, and occipital bones, as far as internal occipital protuberance. Superior sagittal sinus (sup. longitudinal) is enclosed between outer layer of dura and two laminae of falx, along this margin. Concave, *inferior margin* is free, overhangs corpus callosum, contains inferior sagittal sinus (inf. longitudinal) in its posterior $\frac{2}{3}$. At its *base* the laminae are continuous, on each side of median plane, with upper layer of tentorium, and straight sinus lies between falx and tentorium along this line of attachment.

(2) **Tentorium cerebelli**, a crescentic shelf, highest in median plane anteriorly, and sloping to circumference. Forms a tense tent-like roof to posterior cranial fossa, separating its contents from posterior part of cerebrum, which lies on it.

Anterior border or incisura tentorii is deeply concave, sharp and free, except that its anterior ends proceed forwards to be attached to anterior clinoid processes. This border and the dorsum sellæ enclose an opening occupied by mesencephalon. Convex, *circumferential border* is attached to lips of transverse sulcus on occipital bone and mastoid angle of parietal, to upper margin of petrous temporal, and crosses below concave margin to end on posterior clinoid process. After the crossing the attached and free margins, together with a line between ant. and post. clinoid processes, enclose a triangle; trochlear nerve pierces dura at its posterior angle, oculo-motor pierces its floor. Transverse (lateral) sinus is enclosed between two laminae of tentorium and outer layer of dura from int. occipital protuberance to mastoid angle of parietal; and superior petrosal sinus is enclosed along upper border of petrous temporal.

(3) **Falx cerebelli** is a small crescentic fold containing occipital sinus; it projects forwards from internal occipital crest into posterior notch of cerebellum.

(4) **Diaphragma sellæ**, a small circular fold, roofs in fossa hypophyseos (pituitary), and has central aperture for infundibulum. Ant. and post. intercavernous sinuses lie between its laminae at their anterior and posterior attachments.

Arteries to Dura.—Middle meningeal, accessory meningeal, meningeal branches of ethmoidal, ophthalmic, ascending pharyngeal, occipital and vertebral arteries. **Veins** end in sinuses and in mid, meningeal; they communicate with diploic and emissary veins. **Nerves**: from trigeminal, vagus, hypoglossal and sympathetic. **Lymphatics** pass through foramen spinosum, ovale, lacerum, jugulare and magnum, to deep facial and upper deep cervical glands.

Dura Mater Spinalis.—Continuous with inner layer of encephalic dura at for. magnum; descends as a tube to 3rd piece of sacrum, below which it is prolonged as sheath for filum terminale as far as periosteum on dorsum of coccyx. It is adherent to margins of foramen magnum and to 2nd and 3rd cervical vertebrae, and is connected by loose fibrous bands with post. longitudinal lig., towards upper and lower ends of vertebral canal. On each side, anterior and posterior nerve-roots pierce it independently and carry away tubular sheaths, which blend at the spinal ganglion.

Arteries, from various spinal arteries. **Lymphatics** end in deep cervical, intercostal and lumbar glands.

Cavum epidurale is the interval between spinal dura and walls of vertebral canal. It is occupied by fatty areolar tissue and plexus of veins, which correspond in morphological position to venous sinuses of cranium.

Cavum subdurale (subdural space) is capillary interval, containing fluid, between dura and arachnoid of both brain and spinal medulla. It does not communicate with sub-arachnoid space.

Arachnoidea.—Delicate and transparent. Bridges across inequalities of surface of brain, dipping into longitudinal and lateral (Sylvius) fissures only. Forms a loose investment for spinal medulla. Provides sheaths for nerves for a short distance. Ends blindly at level of 2nd sacral vertebra.

Cavum subarachnoideale (subarachnoid space) contains cerebro-spinal fluid, the larger blood-vessels, and a delicate spongework of fibres connecting arachnoid to pia, except over summits of gyri, where they are adherent. In some situations arachnoid and pia are separated by considerable intervals, called cisterns, in which spongework is greatly reduced. **Cisterna cerebello-medullaris (magna)** is formed by arachnoid bridging over wide interval between cerebellum and medulla oblongata. **C. pontis** is interval containing basilar artery on ventral surface of pons. **C. interpeduncularis (basalis)**, interval on base of brain containing circulus arteriosus (Willis). **C. chiasmatis**, anterior to optic chiasma, contains anterior cerebral arteries. **C. fossæ lateralis cerebri** contains middle cerebral artery. Spinal part of subarachnoid space is very wide, and is imperfectly subdivided by ligamenta denticulata and septum sub-arachnoideale. Subarachnoid space communicates with cavities of brain through the *medial aperture* (Magendie) in roof of 4th ventricle and the two *lateral apertures* in its lateral recesses, and by two slits at end of each inferior horn of lateral ventricle. It is contained within arachnoid sheaths of nerves and communicates with their lymph channels, especially olfactory, optic, and acoustic; and it communicates with venous sinuses by osmosis through arachnoideal granulations.

Arachnoideal granulations (Pacchionian bodies) are small pedunculated outgrowths of arachnoid, enclosing subarachnoid spongework, which protrude through lacunæ laterales into superior sagittal (longitudinal) sinus, and occasionally into others. They

produce pits in the bone, called *foveolæ granulares* (Pacchionian depressions), although they are separated from bone by thinned upper wall of sinus and floors of lacunæ, which they push before them. They become conspicuous only as age advances.

Lacunæ laterales or **parasinoidal sinuses** are diverticula from sagittal sinus, and lie in the dura on each side of it.

Pia Mater Encephali.—Thin, delicate; closely invests brain, dipping into all fissures, except in cerebellum, where it occupies only the larger ones. Gives sheaths to cerebral nerves as they pierce it. Blood-vessels ramify in it before sinking into brain substance; they carry pial sheaths into brain substance with them.

Pia mater covering lower part of roof of 4th ventricle is called **tela chorioidea ventriculi quarti**, and is infolded longitudinally over roof of ventricle, on each side of median plane, by a dense plexus of blood-vessels called *plexus chorioideus v. quarti*, which sends an offshoot to bulge in like manner into lateral recess of ventricle. **Tela chorioidea ventriculi tertii** (*velum interpositum*) is a triangular fold of pia mater, projected through transverse fissure into interior of brain, where it lies, below fornix, upon epithelial roof of third ventricle and medial parts of upper surfaces of the two thalami. Apex lies between limbs of foramen interventriculare (Mouro). Base lies below splenium of corpus callosum. There, its upper layer becomes continuous, round splenium, with pia on corpus callosum and hemispheres; its lower layer becomes continuous with pia on mesencephalon. At lateral borders, its layers are continuous with each other and enclose, on each side, a vascular plexus, called *plexus chorioideus v. lateralis*, which is seen, through ependyma of floor of lateral ventricle, at margin of fornix. The plexus communicates with its fellow at apex of tela; is prolonged from postero-lateral angle of tela to the end of inferior (descending) horn of ventricle, being excluded from its cavity only by its ependyma, which it invaginates into horn through chorioidal fissure on its medial side. The enlargement of the plexus as it leaves tela to enter horn is called *glomus chorioideum*. From junction of plexuses at apex of tela a *plexus chorioideus ventriculi tertii* extends backwards between layers of tela, bulging its lower layer and the epithelial roof of 3rd ventricle downwards into cavity of ventricle. *Arteries to plexuses* are chorioid branches of int. carotid and post. cerebral. *Veins* end in int. cerebral veins (Galen), which lie between layers of tela and unite to form vena cerebri magna (Galen). This vein issues from between layers of tela at its base and joins inferior sagittal sinus to form straight sinus.

Pia Mater Spinalis.—Adherent to spinal medulla. Thicker than that of brain. Sends a fold into anterior median fissure and is thickened there, forming a longi-

tudinal band called **linea splendens**. Pia is attached to posterior median septum, and is prolonged as slender filament, 10 inches long, called **filum terminale**, from end of spinal medulla to dorsum of coccyx; lower part of filum is ensheathed in dura. Pia provides sheaths for roots of spinal nerves as they pierce it.

Posteriorly the spinal pia is connected with arachnoid, in median plane, by an imperfect **septum subarachnoideale**. On each side, between anterior and posterior nerve-roots, a longitudinal toothed ridge, called **ligamentum denticulatum**, is attached to pia and suspends spinal medulla in middle of dural tube. The 20 to 22 teeth push arachnoid before them and are attached to dura in intervals between spinal nerves. First tooth is attached between vertebral art. and accessory n., at for. magnum. Last is attached at level of body of 1st lumbar vertebra.

PERIPHERAL NERVOUS SYSTEM

SPINAL NERVES

ARRANGED in pairs. 8 cervical, 12 thoracic, 5 lumbar, 5 sacral, 1 coccygeal. 1st to 7th cervical leave vertebral canal *above* corresponding vertebræ. 8th cervical below 7th vertebra; 1st thoracic to 4th sacral *below* corresponding vertebræ; 5th sacral and 1st coccygeal leave by hiatus sacralis, but their anterior branches turn forwards below corresponding vertebræ.

Typical nerve is connected with spinal medulla by two roots: *anterior*, motor; *posterior*, sensory; and has a *ganglion*. Roots unite, immediately lateral to ganglion, to form **spinal nerve-trunk**, which gives off a recurrent *ramus meningeus* to spinal medulla and its meninges, and then divides into **anterior** and **posterior rami** (ant. and post. primary divisions). Posterior ramus passes dorsally between transverse processes and divides into *rami, lateralis* and *medialis*. Anterior ramus sends a *white ramus communicans* to a ganglion on sympathetic trunk and receives a *grey ramus communicans* from it, and then proceeds laterally and downwards on a plane anterior to transverse processes. During its course it gives off *muscular branches*; and about half-way on its course it gives off **ramus cutaneus lateralis**, which divides into *rami, posterior* and *anterior*. Finally, it ends as **ramus cutaneus anterior** on ventral wall of body. From division of spinal nerve-trunk onwards, the typical arrangement is wholly retained only in thoracic region. Anterior termination is much below level of origin of the nerve, but zone of cutaneous distribution is horizontal or nearly so, owing to droop of lateral cutaneous branch and cutaneous part of posterior branch.

Spinal ganglion consists of cells, each having one process, which divides into two branches, one passing to spinal medulla (cord) in posterior root, the other to periphery in spinal nerve. Ganglion and posterior root of 1st nerve are small and may be absent.

Length of roots increases from above downwards. Since spinal medulla ends at 2nd lumbar vertebra, the lower lumbar, sacral and coccygeal roots have far to travel, and form a leash, called **cauda equina**. Direction of roots of first two nerves is laterally and upwards, of the remainder laterally and downwards, with increasing degrees of obliquity until lowest are vertical.

Lig. denticulatum lies between ant. and post. roots, and, in cervical region, roots of accessory n. also are between them. As each root pierces meninges it gets a close investment from pia mater, a loose sheath from arachnoid as far as dura; a firm sheath from dura mater. When ganglion is reached the dural sheaths of the two roots unite into one, which is prolonged on to nerve-trunk.

Most spinal ganglia and nerve-trunks lie in intervertebral foramina, but those of 1st and 2nd lie above and below posterior arch of atlas; sacral ganglia lie within sacral canal, and coccygeal ganglia within canal of dura mater.

Posterior roots are larger than anterior, except in the case of 1st cervical. Laterally, each posterior root divides into two bundles which join bifid medial end of ganglion; medially, its fibres separate into three groups: (1) *lateral*, composed of very slender fibres which go to form postero-lateral fasciculus (Lissauer); (2) *intermediate*, which passes into substantia gelatinosa; (3) *medial*, which joins fasciculus cuneatus.

The part of the gray ramus communicans which travels inwards along anterior ramus of spinal nerve, to enter and be distributed by post. ramus, sends some fibres along post. root to the meninges. The fibres which leave ant. ramus to form white ramus communicans are contained chiefly in ant. root; those in post. root are probably afferent.

RAMI POSTERIORES

Posterior branches (post. primary divisions) of spinal nerves are smaller than anterior branches, except in case of first two nerves. They divide into medial and lateral branches. In upper half of body, *medial branches* supply muscles and skin, *lateral branches* supply muscles only. In lower half of body, *vice versa*. Therefore cutaneous branches emerge into superficial fascia nearer median plane in upper part of trunk than in lower part.

Cervical Nerves.—1st does not divide into medial and lateral branches. It passes dorsally between vertebral artery and posterior arch of atlas, and supplies semispinalis capitis (complexus), recti capitis posteriores, obliqui, superior and inferior, and communicates with 2nd. Other cervical posterior branches pass dorsally, behind vertebral artery and posterior inter-transverse muscle. 2nd appears below obliquus inferior; its lateral branch receives communicating branches from 1st and 3rd nerves to form *posterior cervical plexus*, and supplies muscles. Medial branch is large and is named **greater occipital n.** It extends upwards and medially over sub-occipital triangle, supplying obliquus inferior and semispinalis capitis (complexus); pierces semispinalis cap. and trapezius, near their attachments; accompanies occipital art., supplying skin of back of scalp.

Medial branch of 3rd forms *n. occipitalis tertius*, which ascends to skin of back of head, after piercing semispinalis capitis and trapezius. Lateral branch supplies muscles. Branches of 4th, 5th, 6th supply skin and muscles of back of neck in typical manner. Both branches of 7th and 8th end in muscles.

Thoracic Nerves supply muscles and skin of back; medial branches of upper six and lateral branches of lower six are cutaneous as well as motor. Before reaching the skin to be supplied, they descend for a distance, increasing from above downwards, till 11th supplies skin at iliac crest, and 12th descends into buttock.

Lumbar Nerves.—Upper 3:—medial branches, to muscles of loin; lateral branches pierce aponeurosis in front of posterior superior iliac spine, and supply skin of buttock as far as greater trochanter. Lower 2 supply muscles only. Lowest communicates with 1st sacral.

Sacral Nerves.—Upper 3:—medial branches, to sacrolumbalis; lateral branches form loops (*posterior sacral plexus*) joined by communication from 5th lumbar and 4th sacral. Branches from primary loops form secondary plexus on surface of sacro-tuberous ligament, from which terminal filaments are distributed to sacrolumbalis, and pierce gluteus maximus to supply skin over back of sacrum and buttock adjoining. Lower 2 do not divide.

Coccygeal Nerve does not divide. It forms loops with lower 2 sacral, which supply skin over coccyx.

RAMI ANTERIORES

Anterior branches (ant. primary divisions) of spinal nerves are larger than posterior, except in case of 1st and 2nd cervical. Distributed to lateral and anterior parts of body and to limbs.

CERVICAL NERVES

1st runs anteriorly, lateral to superior articular surface of atlas, medial to vertebral artery and rectus lateralis. Descends in front of transverse process of atlas to join 2nd. Others appear behind vertebral artery, and pass laterally between intertransverse muscles. Cervical give off no white rami communicantes, but each receives a grey:—first four from sup. cervical ganglion, 5th and 6th from middle, 7th and 8th from inferior.

PLEXUS CERVICALIS

Cervical plexus is a looped plexus. 1st nerve descends to join ascending branch of 2nd. 2nd, 3rd, 4th divide into ascending and descending branches which join with one another and with 1st to form 3 loops. Descending branch of 4th joins brachial plexus. Cervical plexus lies *superficial to* scalenus medius and levator scapulae, *deep to* sterno-mastoid, int. jugular vein, and prevertebral fascia; lateral to scalenus anterior and longus capitis (rectus anticus major).

Branches.—I. **Cutaneous.** appear in post. triangle of neck, above the middle of post. border of sterno-mastoid; diverge from one another and pierce deep fascia:—

(1) **Lesser occipital n.**, from 2nd or 2nd and 3rd, runs along post. border of sterno-mastoid to supply skin of back of head and ear.

(2) **Great auricular n.**, from 2nd and 3rd, ascends upon sterno-mastoid towards ear. Sends *mastoid* branches behind ear. *Auricular* branches to both surfaces of lower part of auricle. *Facial* branches over masseter and parotid; they communicate with facial in substance of parotid.

(3) **N. cutaneus colli** (transverse superficial cervical), from 2nd and 3rd, runs forwards over sterno-mastoid, under platysma; divides into upper and lower branches, which supply skin over anterior triangle of neck.

(4) **Supra-clavicular nerves**, from 3rd and 4th. At first one trunk which divides into 3 sets, *anterior*, *middle*, and *posterior* branches, which pierce deep fascia of roof of posterior triangle and descend, under platysma, over sternal end, middle and acromial end of clavicle respectively, to supply skin covering pectoralis major and deltoid.

II. **Communicating.** Grey rami communicantes from superior cervical ganglion. From 1st, or loop between 1st and 2nd, to hypoglossal; main part of this leaves hypoglossal as *descendens hypoglossi* and *nerves to thyreo-hyoid and genio-hyoid*.

III. **Muscular.** **Lateral:** sterno-mastoid (2nd); levator scapulae (3rd, 4th); trapezius (3rd, 4th); scalenus medius (3rd, 4th).

Medial.—Thyreo-hyoid and genio-hyoid, from 1st, or 1st and 2nd, through communicating branch to hypoglossal. Rectus lateralis, rectus anterior (1st); longus capitis (rectus major) (1st, 2nd, 3rd, 4th); longus colli (3rd and 4th);

intertransversales (2nd, 3rd, 4th) ; scalenus anterior (4th) ; diaphragm from 3rd, 4th (and 5th), through phrenic.

N. descendens cervicalis arises from 2nd and 3rd as two separate nerves which pass downwards and medially, lateral to int. jugular vein ; unite and join descendens hypoglossi to form *ansa hypoglossi* on anterior aspect of carotid sheath. From ansa branches go to sterno-hyoid, sterno-thyreoid, omo-hyoid, which are therefore supplied from 1st, 2nd, 3rd.

Phrenic Nerve.—Arises chiefly from 4th, gets small root from 3rd, and another from 5th, either directly or through n. to subclavius. Descends on anterior surface of scalenus anterior, behind sterno-mastoid ; covered by int. jugular vein near origin, crossed anteriorly by omo-hyoid, transverse cervical artery and transverse scapular artery lower down.

On right side it is separated by scalenus ant. from 2nd part of subclavian artery. Leaves scalenus, descends in front of cervical pleura, behind beginning of innominate vein, crosses int. mammary art. obliquely, latero-medially. Appears in thorax on lateral side of innominate vein ; proceeds to diaphragm, accompanied by pericardiaco-phrenic vessels, having pleura and lung on its right, innominate vein, sup. vena cava, pericardium, and thoracic part of inf. vena cava, successively, on its left ; root of lung and lig. pulmonale behind it.

On left side it leaves scalenus higher up and is crossed superficially by thoracic duct ; passes downwards in front of 1st part of subclavian artery ; crosses int. mammary art. latero-medially ; lies between cervical pleura and subclavian and innominate veins ; appears in thorax from behind lower or left border of innominate vein. Descends in front of subclavian artery, behind and to left side of common carotid, crossing vagus superficially, from behind forwards, above aortic arch. It passes in front of (left side of) aortic arch and proceeds to diaphragm with pericardium on its right, root of lung and lig. pulmonale behind. Pericardiaco-phrenic vessels accompany it, and pleura and lung are on its left side throughout, in the thorax.

Phrenic nerves contain both **motor** and **sensory** fibres, and give **branches** to pleura, pericardium, **diaphragm** (these ramify chiefly on abdominal surface) ; vena cava, suprarenal glands, liver, through communicating branch given to inferior phrenic plexus.

PLEXUS BRACHIALIS

Brachial plexus lies (1) in lower part of posterior triangle, (2) behind clavicle, and (3) in axilla. It is formed by lower four cervical nerves and greater part of 1st thoracic. 4th cervical sends branch to join 5th, and 2nd thoracic sends branch to join 1st. 5th and 6th unite to form *upper trunk*; 7th forms *middle trunk*; 8th and 1st thoracic unite to form *lower trunk*. Trunks each divide, behind and below clavicle, into *ventral* and *dorsal divisions*. Ventral divisions of upper and middle trunks unite to form *lateral cord*. Ventral division of lower trunk forms *medial cord*. All three dorsal divisions unite to form *posterior cord*. (1st TH. gives no fibres to dorsal divisions, or very few.) Cords arrange themselves, according to name, around 2nd part of axillary artery; break up into named nerves at junction of 2nd and 3rd parts, opposite tip of coracoid and lower or lateral border of pectoralis minor.

Branches of Supra-clavicular Part. 1. **Communicating:** grey rami communicantes from middle cervical ganglion to 5th and 6th; from inferior ganglion to 7th and 8th; from 1st thoracic ganglion to 1st thoracic nerve.

II. **Muscular.** A **Anterior:** root of phrenic from 5th; scalenus anterior (5th, 6th); longus colli and intertransverse (5th, 6th, 7th, 8th). **Nerve to subclavius** springs from union of 5th and 6th; descends in front of brachial trunks and subclavian vessels, to end in subclavius.

(B) **Posterior.** Scalenus medius and posterior (5th, 6th, 7th). **N. dorsalis scapulæ** springs from 5th, traverses scalenus medius, descends along vertebral border of scapula, under cover of levator scapulæ, rhomboideus minor and major, supplying all three.

Long thoracic nerve springs from 5th, 6th, 7th. Roots from 5th and 6th pierce scalenus medius, root from 7th passes in front of it, joining others to form one stem, which enters axilla and descends over axillary surface of serratus anterior, supplying it—fibres from 5th to upper part, from 6th to middle, from 7th to lower part.

Suprascapular n. springs from junction of 5th and 6th. Runs laterally and backwards across scalenus medius, above brachial trunks; joins transverse scapular artery. Enters supraspinous fossa below superior transverse lig. of scapula; divides into *supraspinous branch*, which supplies supraspinatus and shoulder-joint, and *infrascapular branch*,

which descends through great scapular notch to supply infraspinatus, and gives another branch to shoulder-joint.

Branches of Infraclavicular Part.—*Lateral cord* gives off lateral anterior thoracic, musculo-cutaneous, lateral head of median. *Medial cord* gives medial anterior thoracic, medial cutaneous nerve of arm, medial cutaneous nerve of forearm, ulnar, medial head of median. *Posterior cord* gives two subscapulars, thoraco-dorsal, axillary, radial.

Lateral anterior thoracic n. (5, 6, 7 C.; lateral cord) passes anteriorly, lateral to 1st part of axillary artery, is connected with medial ant. thoracic by loop in front of artery, pierces costo-coracoid membrane; supplies pectoralis major. **Medial anterior thoracic n.** (8 C., 1 T.; medial cord) passes anteriorly between axillary artery and vein, pierces pectoralis minor, supplying it, and ends in pectoralis major.

Musculo-cutaneous n. (5, 6, C.; lateral cord) lies between axillary artery and coraco-brachialis, pierces coraco-brachialis opposite teres major, and runs distally between biceps and brachialis, supplying them; pierces deep fascia near elbow, at lateral side of biceps; becomes **lateral cutaneous nerve of forearm**, which passes deep to cephalic vein and divides into a *volar* and a *dorsal* branch, for volar and dorsal aspects of radial side of forearm. They end at ball of thumb and dorsum of wrist respectively. **Nerve to coraco-brachialis** from 7 C. or 6 and 7 C. is incorporated with musculo-cutaneous and leaves it before it pierces coraco-brachialis. Branch to brachialis sends twig to elbow-joint.

Median n.—*Lateral head* (5, 6, 7 C.; lateral cord) lies on lateral side of axillary art. *Medial head* (8 C., 1 T.; medial cord) passes distally and laterally, on anterior surface of axillary art., to join lateral head. Median nerve trunk lies along lateral side of axillary and brachial arteries as far as middle of arm, crosses brachial art. there, usually superficially but sometimes deep to it, and lies along its medial side as far as cubital fossa, where it lies on medial side of ulnar artery. Leaves fossa between two heads of pronator teres, ulnar head separating it from ulnar artery; passes towards wrist between flex. sublimis and profundus, closely adherent to sublimis. Near wrist it becomes more superficial, lying on ulnar side of flex. carpi radialis, dorsal to or on radial side of palmaris longus. Passing deep to transverse carpal lig., and overlapped by lateral part of synovial flexor sheath, it enters palm and divides into medial and lateral divisions.

Median branch of volar interosseous art. accompanies it in forearm.

Branches.—None in axilla or (upper) arm.

In forearm.—**Muscular** : branches near elbow to pronator teres, flex. carpi radialis, palmaris longus, flex. sublimis. Some of these are continued to elbow joint as *articular branches*. *Volar interosseous n.* (ant. interosseous) arises after median has passed between heads of pronator teres ; sinks dorsally to reach interosseous membrane ; runs distally, close to it, superficial to volar interosseous vessels ; gives branches to flex. pollicis longus and radial half of flex. profundus ; passes dorsal to pronator quadratus, which it supplies, and ends in volar ligaments of radio-carpal and carpal joints. **Cutaneous** : *palmar branch* pierces deep fascia between flex. carpi radialis and palmaris longus, crosses transverse carpal lig. to supply skin of lateral and median parts of palm.

In palm (see also p. 151).—**Lateral division** supplies abductor and flexor pollicis brevis and opponens ; digital branches to both sides of thumb and radial side of forefinger ; 1st lumbrical is supplied by the branch to forefinger.

Medial division splits into digital branches to supply contiguous surfaces of index and medius, and medius and annularis. The more lateral of these supplies 2nd lumbrical ; the other sometimes supplies 3rd lumbrical. Digital nerves supply sides and volar surfaces of the digits and also dorsum of 2nd phalanx of thumb and of 2nd and 3rd phalanges of other 2½ digits.

Ulnar n. (8 C., 1 T. ; medial cord) lies between axillary art. and vein ; runs distally along medial side of brachial artery to middle of (upper) arm, where it diverges medially, and, accompanied by sup. ulnar collateral vessels (inferior profunda), pierces medial intermuscular septum. It runs towards elbow upon medial head of triceps, crosses back of medial epicondyle and ulnar collateral ligament ; enters forearm between heads of flex. carpi ulnaris ; traverses forearm, lying upon flexor profundus, covered by flexor carpi ulnaris in proximal half ; superficial in distal half, with flex. carpi ulnaris on ulnar side, ulnar art. and flex. sublimis on radial side. In proximal $\frac{1}{3}$ of forearm ulnar artery and nerve converge : in distal part they lie side by side, the nerve on ulnar side. Proximal to wrist they pierce deep fascia, leave flexor profundus and lie upon transverse carpal lig. (ant. annular), under cover of volar carpal ligament, at

radial side of pisiform ; leave transverse lig. and lie upon lig. piso-hamatum (pisi-unciform lig.) and ulnar side of hook of os hamatum (unciform), under cover of palmaris brevis, where the nerve divides into superficial and deep divisions.

Branches.—None in axilla and (upper) arm.

At elbow.—*Articular* branch. *Muscular* to flex. carpi ulnaris and ulnar $\frac{1}{2}$ of flex. digitorum profundus.

In distal third of forearm.—*Ramus cutaneus palmaris* pierces deep fascia, crosses transverse carpal lig., supplies skin of medial part of palm. *Ramus dorsalis manus*, winds dorsally under flex. carpi ulnaris ; pierces deep fascia, gives branches to skin of wrist and hand, to ulnar side of little finger, contiguous sides of little and ring fingers, and joins radial in supplying contiguous sides of ring and middle fingers.

In palm.—*Ramus superficialis* supplies palmaris brevis, skin of medial part of palm, of ulnar side of little finger and contiguous sides of little and ring fingers. *Ramus profundus* accompanies deep branch of artery, supplies muscles of little finger, runs across palm with deep volar arch and supplies all seven interossei, medial two lumbricals, adductor pollicis (both parts) and deep head of flex. pollicis brevis (*v.* p. 151).

Medial cutaneous n. of arm (Lesser int. cut.) (1 T. ; medial cord) passes posterior to axillary vein to reach its medial side ; pierces deep fascia and supplies skin of medial side of (upper) arm.

Medial cutaneous n. of forearm (Int. cutaneous) (8 C., 1 T. ; medial cord) arises in front of ulnar, runs distally on ant. surface of axillary art. and first inch of brachial, afterwards on medial side of brachial art. Leaves it at middle of arm to pierce deep fascia. It divides into *volar* and *ulnar branches*, for supply of skin on volar and dorsal aspects of ulnar side of forearm, respectively. Volar branch passes posterior to, but sometimes anterior to, median basilic vein.

Subscapular nerves (5, 6 C. ; posterior cord). *Upper* sinks into subscapularis. *Lower* runs downwards and laterally over subscapularis, supplying it, and ends in teres major. See also p. 135.

Thoraco-dorsal n. (Long subscapular) (6, 7, 8 C. ; posterior cord) runs downwards and posteriorly, across subscapularis and teres major, to end in latissimus dorsi. See also p. 135.

Axillary n. (Circumflex (5, 6 c.; posterior cord) runs distally between axillary artery and subscapularis; then dorsally through quadrilateral space; gives *articular* branch to shoulder, and divides into anterior and posterior divisions. **Posterior division** gives branches to teres minor and deltoid, and, turning round posterior border of deltoid, becomes *lateral cutaneous n. of arm*, which supplies skin over distal part of deltoid. **Anterior division** accompanies post. humeral circumflex vessels, around surgical neck of humerus, under cover of deltoid, to which it is distributed, some branches piercing the muscle to supply skin. See also p. 135.

Radial n. (Musculo-spiral) (5, 6, 7, 8 c., sometimes 1 r.; posterior cord) runs distally, posterior to axillary art., then between first inch of brachial art. and long head of triceps. Leaves medial side of arm, between long and medial heads of triceps, accompanied by profunda vessels; crosses to lateral side, in groove on back of humerus, between medial and lateral heads of triceps; pierces lateral intermuscular septum, accompanied by ant. branch of profunda; and, running distally between brachialis and brachio-radialis, it ends just proximal to elbow, between brachialis and ext. carpi radialis longus, by dividing into *superficial* and *deep* branches, which lie in contact with capsule of elbow, anterior to capitulum of humerus.

Branches.—In axilla and medial side of arm: *Muscular* to long and medial heads of triceps. *Posterior cutaneous n. of arm* (Int. cutan. of musculo-spiral) pierces fascia near axilla, crosses posteriorly over intercosto-brachial and supplies skin on medial side of back of arm. **On back of arm:** *Muscular* to all three heads of triceps, and branch to anconeus, which descends through medial head of triceps. *Dorsal cutaneous n. of forearm* (ext. cutan. of musculo-spiral) arises as two branches, which pierce deep fascia, distal to insertion of deltoid. *Proximal* supplies skin on antero-lateral aspect of distal half of arm and adjoining dorsum of forearm. *Distal* supplies skin along middle of dorsum of forearm. **On lateral side of arm:** *Muscular* to brachialis, brachio-radialis, ext. carpi rad. longus. *Articular* to elbow. Superficial and deep *terminal* branches.

Ramus superficialis (Radial) runs distally, under cover of brachio-radialis, upon elbow-joint, supinator and anterior borders of ext. carpi radiales, lateral to radial artery. In distal third it inclines posteriorly, upon tendon of ext. carpi rad.

longus ; appears from under brachio-radialis, descends upon superficial aspect of abductor pollicis longus and ext. poll. brevis ; pierces deep fascia, crosses dorsal carpal lig. (post. annular) at lateral side of distal end of radius, breaking up into diverging branches which cross wrist-joint at hollow on radial side of wrist, and pass over the radial artery and extensors of thumb to be distributed to the radial part of dorsum of hand, radial side of thenar eminence, proximal part of dorsum of thumb, index, medius, and half of annularis.

Ramus profundus (posterior interosseous) gives branches to supinator, and ext. carpi rad. brevis, and passes round lateral side of radius, through substance of supinator, to reach back of forearm, where it is called **dorsal interosseous n.**, and lies on supinator, abductor pollicis longus, interosseous membrane and dorsum of wrist. At wrist it breaks up into branches for radio-carpal and carpal joints. On dorsum of forearm it supplies ext. dig. communis, dig. quinti proprius, carpi ulnaris ; abd. poll. longus, ext. poll. longus and brevis, and indicis proprius.

THORACIC NERVES

Anterior ramus of a typical thoracic nerve gives a white ramus communicans to sympathetic and receives a grey one from it. It passes laterally, in front of anterior costo-transverse lig. and posterior intercostal membrane ; slips in between ext. and int. intercostals, and runs anteriorly below corresponding rib and intercostal vessels. Each sends a branch through post. intercostal membrane and ext. intercostal muscle to a levator costæ ; upper 3 or 4 send branches to serratus posterior superior ; 9th, 10th, 11th send branches to serratus inferior. Less than half-way round chest each gives off *lateral cutaneous branch*, and then passes obliquely through int. intercostal muscle, and proceeds medially, deep to it and in front of pleura, transversus thoracis and int. mammary vessels, to reach side of sternum, where it turns anteriorly through int. intercostal muscle, ant. intercostal membrane, pectoralis major and its fascia, to end as *anterior cutaneous branch* on front of chest. It supplies intercostals, subcostals, and transversus. **Ramus cutaneus lateralis** pierces ext. intercostal, supplying it ; divides, under serratus anterior, into

anterior and *posterior branches*, which pierce or appear between digitations of serratus, and are directed, the one anteriorly over pectoralis major, the other posteriorly over latissimus dorsi.

First thoracic nerve gives off no white ramus communicans. It joins brachial plexus, but sends small **intercostal nerve** across pleural surface of 1st rib into 1st space; this gives off no lateral or anterior cutaneous branches.

Second to eleventh, inclusive, are **intercostal**. Upper 6 intercostals are thoracic, lower 5 are thoraco-abdominal in distribution. Second sends a communicating branch to first. Its *lateral cutaneous branch* is called **intercosto-brachial**, and stretches across axilla to the arm and supplies skin of floor of axilla and posterior part of medial side of arm. Posterior branch of lateral cutaneous of third may cross axilla to skin of arm. Seventh to eleventh, at ends of intercostal spaces, pass between digitations of diaphragm into abdominal wall; proceed medially between obliquus internus and transversus, enter sheath of rectus at its lateral edge, turn anteriorly, through rectus and anterior wall of its sheath, to end in skin of abdomen, seventh supplying region of xiphoid process, tenth, the region of umbilicus. They also supply obliqui, transversus, and rectus. Their *lateral cutaneous branches* supply skin of abdomen as well as thorax, and that of eleventh extends on to buttock slightly.

Twelfth thoracic nerve passes dorsal to upper end of psoas major, appears in abdomen from behind lateral lumbo-costal arch [ext. arcuate lig.]; runs with subcostal vessels across anterior surface of quadratus lumborum, posterior to kidney; pierces transversus and then follows course of a lower intercostal. Besides obliqui, etc., it supplies pyramidalis. Its *ramus cutaneus lateralis* pierces obliqui, descends over iliac crest, anterior to its tubercle, and supplies skin of buttock, as far as trochanter major.

LUMBAR, SACRAL, AND COCCYGEAL NERVES

Anterior rami form the *plexus lumbo-sacralis*, subdivided into lumbar, sacral, pudendal and coccygeal plexuses. They receive grey rami communicantes from sympathetic. White rami communicantes are given by 1 and 2 L. to sympathetic trunk, and by 3 and 4 S. to sympathetic pelvic plexus.

PLEXUS LUMBALIS

Lumbar plexus is formed by first 3 and part of 4th lumbar, and receives a communicating branch from 12th thoracic. It lies in substance of psoas major, on anterior surfaces of transverse processes. 1st nerve supplies psoas minor; 1st, 2nd, 3rd, 4th supply quadratus lumborum; 2nd, 3rd, and 4th supply psoas major and iliacus. The following named nerves arise from plexus:—

Ilio-hypogastric n. (1 L. or 12 T., 1 L.) appears at lateral border of psoas; runs across quadratus, posterior to kidney; pierces posterior aponeurosis of transversus; passes anteriorly, above iliac crest, between transversus and obliquus internus; pierces obliquus internus, 1 inch in front of anterior iliac spine, and becomes *ramus cutaneus anterior* by piercing aponeurosis of obliquus externus, about 1 inch above subcutaneous inguinal ring. Supplies muscles between which it lies. Its *ramus cutaneus lateralis* pierces obliqui and descends over tubercle of iliac crest to supply skin of buttock.

Ilio-inguinal n. (1 L., or 12 T. and 1 L.). Nearly same course as ilio-hypogastric, but is lower down; gives off no lateral branch; pierces obliquus internus further forwards; becomes superficial by passing through subcutaneous inguinal ring and external spermatic fascia. Supplies muscles between which it passes, skin of lower part of abdominal wall, of upper medial part of femoral trigone (Scarpa), of upper part of scrotum and penis, or labium majus.

Genito-femoral n. (Genito-crural) (1, 2 L.) pierces psoas major, descends on its anterior surface, deep to ureter and branches of mesenteric vessels; divides into two: (1) **ext. spermatic n.** descends upon termination of external iliac artery, enters inguinal canal, supplies cremaster muscle, ends in skin of scrotum and adjacent thigh. (2) **Lumbo-inguinal n.** descends on lateral side of ext. iliac and femoral arteries, pierces deep fascia to supply skin of proximal part of front of thigh.

Lateral cutaneous n. of thigh (2, 3 L.) appears at lateral border of psoas, above iliac crest; runs across iliacus to anterior superior iliac spine, deep to fascia iliaca, posterior to caecum on right side, iliac colon on left side; enters thigh behind inguinal ligament (Poupart), and, passing superficial or deep to origin of sartorius, pierces deep fascia

4 inches distal to it ; gives **posterior branch** to side of buttock and adjoining thigh, and **anterior branch** to antero-lateral aspect of thigh, as far as knee.

Obturator n. (2, 3, 4 L.) crosses upper surface of sacro-iliac joint, lateral to lumbo-sacral trunk, and separated from trunk by ilio-lumbar art. : appears at medial side of psoas, posterior to common iliac artery ; runs downwards and anteriorly along side wall of pelvis, lateral to hypogastric (int. iliac) vessels and ureter, below obliterated umbilical art., above obturator vessels. Leaves pelvis through upper part of obturate foramen, and divides in the foramen into two branches :—**Ramus anterior** sends a branch to hip-joint through acetabular notch, and then runs distally, posterior to pectineus and adductor longus, anterior to obturator externus and adductor brevis ; supplies adductor longus and brevis, gracilis and sometimes pectineus ; ends by dividing into a branch for femoral artery in adductor canal (Hunter's) and a cutaneous branch for medial side of thigh. **Ramus posterior** gives a branch to obturator externus, then pierces that muscle, and extends distally between adductor brevis and magnus, supplying magnus ; ends as geniculate articular branch, which pierces magnus and runs along popliteal artery to back of knee-joint. This geniculate branch is very rarely seen.

Accessory obturator nerve (3 L. or 3 and 4 L.), only occasionally present (29 per cent.). Descends along medial border of psoas, enters thigh above superior ramus of pubis. May end in pectineus or in hip-joint, or may be a substitute for obturator to a varying extent.

Femoral n. (Anterior crural 2, 3, 4 L., posterior to obturator) appears at lateral border of psoas, below iliac crest ; gives branches to psoas and iliacus, and, descending between them, posterior to cæcum on right side, to iliac colon on left side, it leaves abdomen behind inguinal ligament, and breaks up into branches, a little lateral to femoral art., in femoral trigone (Scarpa). Supplies pectineus, sartorius, rectus femoris, all three vasti, and articularis genu. Branch to pectineus passes posterior to femoral sheath. Branch to rectus femoris supplies hip-joint. Branches to vasti are continued to knee-joint. Branch to v. medialis lies on lateral side of femoral art. before entering muscle. **Medial cutaneous nerve** (Int. cutaneous) passes distally and medially across femoral vessels ; divides into two

branches, *anterior* and *posterior*, which supply skin of medial side of thigh, and proximal part of leg. **Intermediate cutaneous nerve** (Middle cutaneous) consists of *medial* and *lateral* branches which supply skin of distal $\frac{2}{3}$ of front of thigh. **Saphenous n.** runs distally and medially; traverses adductor canal (Hunter); pierces deep fascia at medial side of knee, between tendons of sartorius and gracilis; accompanies great saphenous vein as far as middle of medial border of foot. Before piercing fascia it gives off *ramus infra-patellaris*, which ramifies on anterior surface of patella and lig. patellæ.

Obturator or sub-sartorial plexus consists of communications between saphenous, medial cutaneous, and cutaneous branch of obturator, on fibrous roof of adductor canal.

Patellar plexus is formed on anterior surfaces of patella, lig. patellæ, and proximal part of tibia by communications between lateral, medial, and intermediate cutaneous nerves, and infra-patellar branch of saphenous.

PLEXUS SACRALIS

Sacral plexus is formed by descending part of 4th lumbar, 5th lumbar, 1st sacral, greater part of 2nd, upper, smaller part of 3rd sacral. These converge towards lower part of greater sciatic foramen to form sciatic nerve. Lower part of 4th lumbar descends along medial side of psoas, posterior to common iliac artery; 5th lumbar descends upon ala of sacrum, and is joined by descending part of 4th, and the two form the *lumbo-sacral trunk*, which passes obliquely across sacro-iliac joint, behind hypogastric vessels (int. iliac), to join 1st sacral, the superior gluteal artery passing dorsally and laterally between them, before their junction. First sacral nerve crosses sacro-iliac joint at upper border of piriformis. Lower part of plexus lies on piriformis, *behind* pelvic fascia, branches of hypogastric (int. iliac) vessels and ureter. Each of the nerves, except the contribution from 3rd sacral, consists of ventral and dorsal parts. Dorsal parts give rise to nerves springing from posterior aspect of plexus and common peroneal branch of sciatic. Ventral parts and contribution from 3rd give rise to nerves springing from ant. aspect of plexus, and they form the tibial division of sciatic.

Branches from Anterior Aspect of Plexus.—N. to quadratus femoris (4, 5 L., 1 S.) leaves pelvis below piriformis ; runs distally on hip bone and post. surface of hip joint, in front of sciatic nerve, obturator internus, and gemelli. Gives branches to hip-joint and gemellus inferior, and enters deep (anterior) surface of quadratus femoris.

N. to obturator internus (5 L., 1, 2 S.) leaves pelvis through greater sciatic foramen, below piriformis ; crosses base of ischial spine, supplies gemellus superior, enters ischio-rectal fossa, through lesser sciatic foramen, and supplies obturator internus, entering it on its perineal surface.

Branches from Posterior Surface of Plexus.—Nerves to piriformis from 1 and 2 S. **Superior gluteal n.** (4, 5 L., 1 S.) leaves pelvis through greater sciatic foramen, above piriformis ; extends laterally and forwards between gluteus medius and minimus, supplying them, and ends in deep surface of tensor fasciæ latæ, supplying it also.

Inferior gluteal n. (5 L.; 1, 2 S.) leaves pelvis below piriformis, posterior to sciatic nerve, and supplies gluteus maximus.

Posterior cutaneous n. of thigh (Small sciatic) (1, 2, 3 S.) belongs partly to pudendal plexus. Leaves pelvis with inferior gluteal. Passes distally under cover of gluteus maximus, posterior to or medial to sciatic nerve. Sends branches round lower border of gluteus maximus to skin of buttock ; sends branches to medial side of thigh ; and its *perineal branch* (long pudendal) crosses hamstring tendons just distal to ischial tuberosity, enters superficial perineal pouch and is carried anteriorly to skin of scrotum or labium, and of root of penis or clitoris. Having given off these branches, the posterior cutaneous n. extends distally, under deep fascia, to popliteal fossa, where it pierces deep fascia and supplies skin of calf of leg. In back of thigh it sends branches through deep fascia at intervals.

Nervus ischiadicus sciatic (4, 5 L. ; 1, 2, 3 S.) leaves pelvis through greater sciatic foramen, between its lower margin and piriformis ; traverses buttock and proximal part of thigh and ends at middle of thigh by dividing into tibial and common peroneal nerves (internal and external popliteal).

In buttock it lies under cover of gluteus maximus and crosses (1) dorsum of acetabulum, and n. to quadratus, (2) obturator internus and gemelli, (3) quadratus femoris. N. to obturator internus is medial to it ; inf. gluteal nerve and

vessels and post. cutaneous nerve are superficial or medial to it.

In thigh, adductor magnus is anterior, and long head of biceps crosses it posteriorly, from medial to lateral side.

When its terminal branches arise directly from sacral plexus, the tibial nerve appears below piriformis, but common peroneal pierces it. When this occurs the post. cutaneous (small sciatic) also is divided; ventral part (1, 2 s.) accompanies tibial; dorsal part (2, 3 s.) accompanies peroneal.

In thigh, sciatic gives branches to semitendinosus, semimembranosus, long head of biceps and adductor magnus from its tibial part; to short head of biceps from peroneal part.

Common peroneal n. (External popliteal) (4, 5 l.; 1, 2 s.), smaller terminal branch of sciatic. Begins at middle of back of thigh; enters apex of popliteal fossa, from under cover of biceps; proceeds along medial side of biceps; passes through lateral angle of fossa, and on to back of head of fibula, where it is most superficial and easily felt; enters substance of peronæus longus on lateral side of neck of fibula, where it divides into terminal branches—superficial and deep peroneal. See also p. 179.

Branches.—Lateral sural; anastomotic; articular, including recurrent; terminal branches. *Lateral sural n.* arises in fossa; supplies skin on antero-lateral aspect of proximal part of leg. *Ramus anastomoticus peronæus* (Communicans fibularis) pierces deep fascia and joins medial sural nerve to form nervus suralis. *Two articular branches* accompany lateral genicular arteries. *Recurrent articular nerve* arises at termination of common peroneal, pierces ext. digitorum longus, turns proximally, with ant. recurrent art., into tibialis anterior; supplies it, and tibio-fibular and knee joints.

Superficial peroneal n. (Musculo-cutaneous) emerges from peronæus longus, runs distally, anterior to peronæus longus and brevis, supplying them, and posterior to ext. longus digitorum; divides into two branches which pierce fascia in distal $\frac{1}{3}$ of leg, and supply skin of distal $\frac{1}{3}$ of leg, and of dorsum of foot. Medial branch supplies also distal part of medial border of foot, medial side of great toe, contiguous sides of 2nd and 3rd, and assists deep peroneal in supplying first cleft. Lateral branch supplies skin of 3rd and 4th clefts.

Deep peroneal n. (Anterior tibial) emerges from peronæus longus, pierces ext. digitorum longus, approaches ant. tibial

vessels, lies anterior to artery in middle $\frac{1}{3}$ of leg, and on its lateral side in distal $\frac{1}{3}$; supplies ext. digitorum longus, peronæus tertius, ext. hallucis longus, tibialis anterior, ankle joint. Passes behind transverse and cruciate ligaments (ant. annular) and divides into medial and lateral branches. *Medial branch* runs distally to supply skin of contiguous sides of great and 2nd toes. *Lateral branch* turns laterally and ends under ext. digitorum brevis by supplying it and neighbouring joints. See also p. 190.

Tibial n. (Int. popliteal and post. tibial), larger terminal branch of sciatic. Begins at middle of back of thigh; traverses popliteal fossa from proximal to distal angle, superficial to popliteal vessels, crossing them latero-medially. In leg it is covered by soleus proximally, deep fascia and lig. laciniatum (int. annular) distally. Tibialis posterior, flexor digitorum and tibia are anterior to it, successively. At first it is on medial side of post. tibial art., but crosses it posteriorly at origin of peroneal, and beyond that it is on lateral side. It ends under lig. laciniatum (int. annular) by dividing into medial and lateral plantar nerves.

Branches in Popliteal Fossa.—(1) *Muscular* branches to both heads of gastrocnemius, plantaris, soleus, popliteus. (2) *Articular* branches accompany middle and both medial genicular arteries. (3) *Medial sural n.* (Communicans tibialis), pierces deep fascia, joins anastomotic peroneal to form *nervus suralis* (short or ext. saphenous), which accompanies small saphenous vein behind lateral malleolus, and supplies skin on lateral border of foot and little toe.

Branches in Back of Leg.—(4) *Muscular* to soleus, tibialis posterior, flex. hallucis longus and flex. digitorum longus. (5) *Articular* to ankle-joint. (6) *Medial calcanean* pierce lig. laciniatum to supply skin of plantar surface of heel. (7) *Terminal* branches—medial and lateral plantar.

Medial plantar n. (see also p. 185), larger terminal branch of tibial, corresponds to median in hand. Accompanies medial plantar artery. Gives 4 *digital* branches—to medial side of great toe and contiguous sides of great toe and next three; *cutaneous* branches to medial side of sole; *muscular* to abductor hallucis and flexor dig. brevis from its trunk, to flex. hall. brevis from 1st digital branch, to 1st lumbrical from 2nd digital branch.

Lateral plantar n. (see also p. 186) corresponds to ulnar nerve in hand. It accompanies lateral plantar artery to

base of 5th metatarsal, where it divides into superficial and deep branches. From its trunk it supplies quadratus plantæ and abductor digiti quinti, and skin of sole. *Ramus superficialis* divides into two: lateral branch supplies flexor digiti quinti brevis, 3rd plantar and 4th dorsal interossei, skin of sole and lateral side of little toe. Medial branch supplies contiguous sides of 4th and 5th toes. *Ramus profundus* accompanies plantar arch, and supplies remaining interossei, adductor hallucis, lateral three lumbricals.

PLEXUS PUDENDUS

Pudendal plexus overlaps sacral plexus. Lies upon piriformis and coccygeus, behind rectum. Formed by parts of 2nd and 3rd and 4th sacral.

Muscular branches are given by 3rd and 4th to levator ani and coccygeus.

Visceral branches (white rami communicantes) pass from 3rd and 4th to pelvic viscera, partly directly and partly through pelvic sympathetic plexuses, which they join.

The following named nerves arise from plexus:—

Perineal branch of 4th sacral leaves pelvis, enters posterior angle of ischio-rectal fossa, and proceeds upon levator ani to sphincter ani externus. See also p. 250.

Perforating cutaneous (2, 3 S.) pierces sacro-tuberous (great sacro-sciatic) lig. and lower border of glutæus maximus, and supplies skin of buttock. See also p. 251.

Pudendal n. (int. pudic) (2, 3, 4 S.) leaves pelvis through greater sciatic foramen, between piriformis and coccygeus; crosses dorsal surface of sacro-spinous ligament, enters ischio-rectal fossa by passing through lesser sciatic foramen; enters Alcock's canal, and at once divides into inf. hæmorrhoidal, perineal and dorsal n. of penis.

(1) *N. hæmorrhoidalis inferior* accompanies inf. hæmorrhoidal vessels through medial wall of Alcock's canal, across ischio-rectal fossa; supplies ext. sphincter and skin around anus.

(2) **Perineal n.** divides, near urogenital diaphragm, into superficial and deep branches, which pierce conjoined posterior borders of fasciæ of urogenital diaphragm (triangular lig.). *Superficial* consists of medial and lateral *posterior scrotal* or *labial nerves*, which run over superficial perineal muscles to scrotum or labium majus. *Deep branch* supplies

sphincter urethræ, deep and superficial transverse perineal, ischio-cavernosus, bulbo-cavernosus, and bulb of urethra ; or corresponding parts in female.

(3) *N. dorsalis penis vel clitoridis* accompanies int. pudendal artery on its lateral side, between fasciæ of urogenital diaphragm, close to pubic arch. It sends a branch, through inferior fascia, to corpus cavernosum penis, and, piercing inferior fascia itself, $\frac{1}{2}$ inch below symphysis, it passes on to dorsum of penis or clitoris to reach glans, where it ends. On dorsum it lies lateral to dorsal vessels.

PLEXUS COCCYGEUS

Fifth sacral and coccygeal nerves descend from hiatus sacralis, pierce coccygeus, join and form **coccygeal plexus**, which is joined by branch from 4th sacral. From the plexus, branches pass dorsally to skin over coccyx and behind anus. See also p. 250.

CEREBRAL (CRANIAL) NERVES

Olfactory Nerves (1st nerve, special sense) consist of about 20 filaments on each side, which arise in olfactory mucous membrane, pass through lamina cribrosa of ethmoid, and end in olfactory bulb.

Optic Nerve (2nd, special sense) begins at chiasma, and is formed by fibres of optic tract of same side and fibres of opposite tract which cross in chiasma. Enters orbit through optic foramen, enclosed in sheath derived from membranes of brain ; passes anteriorly and laterally, pierces sclera and chorioid and retina, 1 mm. below and 3 mm. on nasal side of posterior pole of eyeball, and spreads out on inner surface of retina.

Relations.—*In cranial cavity.*—Int. carotid and ophthalmic arteries are below and lateral to it ; olfactory tract is above it. *In optic foramen.*—Ophthalmic artery is below and lateral to it. *In orbit.*—It is surrounded by orbital muscles, fascia bulbi (capsule of Tenon), fat, ciliary vessels and nerves. Inferior division of oculo-motor and inf. ophthalmic veins are below it ; naso-ciliary n. crosses latero-medially, above it ; ophthalmic art. and sup. ophthalmic vein also cross, latero-medially, above it, but sometimes below it ; ciliary ganglion and abducent nerve are lateral to it. Arteria centralis retinæ enters its lower and medial aspect.

Connections.—Fibres of optic nerve nearly all arise in retina.

a few delicate filaments end in it. At **chiasma**, fibres from lateral and larger half of retina run into **tract** of same side, fibres from medial half cross to opposite tract. Right optic tract, therefore, contains fibres of right halves of both retinae, and left receives fibres from left halves. In region of geniculate bodies fibres enter lateral root of tract and end in **lateral geniculate body**, **pulvinar** of thalamus, and some are carried in superior brachium to **sup. corpus quadrigeminum**. These are lower visual centres, and are connected with higher centres in occipital cortex by optic radiation; and superior corpus quadrigeminum is connected also with nuclei of nerves of ocular muscles by fibres which join medial longitudinal bundle. **Optic radiation** (B.N.A. radiatio occipito-thalamica) is a broad sheet of fibres in white substance of occipital lobe, between inferior longitudinal fasciculus laterally and tapetum medially, which separates it from ependyma of ventricle. Traced posteriorly, it spreads out and ends on medial and lateral surfaces of **occipital lobe**; traced anteriorly it enters retro-lenticular part of internal capsule, and its fibres at once pass to lower visual centres and nuclei of oculo-motor nerves. It consists of (1) fibres which arise in lateral geniculate body and pulvinar, and end in occipital cortex; (2) fibres arising in occipital cortex and ending in pulvinar, sup. corp. quad. and oculo-motor nuclei.

Oculo-motor Nerve (3rd).—*Motor* to most of muscles of orbit and eyeball. Emerges from oculo-motor sulcus of mesencephalon; passes anteriorly, downwards and laterally, in cisterna interpeduncularis, between posterior cerebral and superior cerebellar arteries; pierces dura mater in middle fossa, in floor of triangle formed by free and attached borders of tentorium; traverses lateral wall of cavernous sinus, above other nerves there; is crossed on its lateral side, from below upwards, by trochlear nerve, near anterior end of cavernous sinus; and divides into two branches, which enter orbit through superior orbital (sphenoidal) fissure, between heads of rectus lateralis, having naso-ciliary (nasal) nerve between them. **Ramus superior** passes through rectus superior, supplying it, and ends in levator palpebrae. **Ramus inferior** supplies rectus medialis and inferior, and obliquus inferior. From nerve to obliquus it gives additional branch to rectus inferior and short root (motor) to ciliary ganglion.

Nucleus.—Cells in ventral part of grey matter around aquæductus cerebri (Sylvii), on a level with sup. corp. quad. It also extends upwards into side wall of 3rd ventricle. **Fibres** arch ventrally through medial longitudinal bundle, red nucleus, medial margin of substantia nigra, and emerge through sulcus at medial side of basis pedunculi (crusta).

Communications.—**Nucleus** receives fibres from area for movements of eyes (middle and inferior frontal gyri of opposite side); from visual centre in occipital lobe, through optic radiation; from sup. corp. quad. Is connected with cerebellum through brachium conjunctivum (sup. cerebellar peduncle); with nuclei of trochlear and abducent, and of sensory nerves, through medial longitudinal bundle. Sends fibres to join those of opposite side which go to rectus medialis; and sends fibres through medial long. bundle to join 7th n. and to end in orbicularis oculi, corrugator supercilii, and frontalis. **Fibres**: from opposite abducent through med. long. bundle to join fibres going to rectus medialis or the nuclear cells of these fibres. **Nerve**: from sympathetic and from ophthalmic nerve in cavernous sinus.

Trochlear Nerve (4th).—*Motor* to sup. oblique of orbit. Smallest of cerebral nerves. Emerges through ant. medullary velum, turns round mesencephalon; appears at base between posterior cerebral and superior cerebellar arteries; pierces dura at posterior angle of triangle between attached and free borders of tentorium; courses anteriorly in lateral wall of cavernous sinus, below oculo-motor; crosses oculo-motor from below upwards, passes through superior orbital fissure, above rectus lateralis; crosses medially, above levator palpebrae, and sinks into upper border of obliquus superior, near its origin.

Nucleus.—Cells in ventral part of grey matter of aqueduct, on level with upper part of inf. corp. quad. **Fibres** curve first dorsally, then caudally, lastly medially to enter anterior (superior) medullary velum, where they decussate with their fellows, and emerge along medial margin of opposite brachium conjunctivum (sup. cerebell. ped.).

Communications—**Nucleus** (1) motor centre of opposite hemisphere; (2) nuclei of oculo-motor and abducent and of sensory nuclei, through medial longitudinal bundle; (3) cerebellum, through brachium conjunctivum. **Nerve**: from sympathetic and ophthalmic in cavernous sinus.

Trigeminal Nerve (5th).—Largest of cerebral nerves. *Sensory* for face, front of head, nose, mouth, ant. $\frac{2}{3}$ of tongue, teeth. *Motor* for muscles of mastication. Has a motor root and a sensory root with a ganglion. **Portio minor** is its motor root. Ganglion of sensory root is **semilunar ganglion**, cells of which send branches centrally to form **portio major**, which is the sensory root, and branches peripherally in three divisions called ophthalmic, maxillary, and mandibular nerves.

Sensory Nuclei.—Portio major reaches pons at its junction with brachium pontis (middle cerebellar peduncle), and nearer its upper border than lower. It sinks dorsalwards for $\frac{1}{2}$ inch, and its fibres divide into short superior and long inferior branches. Superior branches end at once in a nucleus placed half-way up tegmentum of pons, just ventral to submerged edge of brachium conjunctivum (sup. cer. ped.). Inferior branches form **tractus spinalis** (spinal root of V.), which descends through pons, with vestibular nerve and restiform body on its lateral side, and emerging trunk and nucleus of facial on medial side. Entering medulla oblongata, it lies nearer surface, on ventral aspect of restiform body, and is traversed, and broken up into bundles, by cerebello-olivary fibres and vago-glossopharyngeal roots, and is crossed superficially by cerebello-spinal fasciculus (direct cerebellar tract). Finally it comes quite to surface and extends, on ventral side of funiculus cuneatus, as far as level of 2nd cervical nerve. The fibres end in a nucleus which is applied to its inner surface throughout, and is continuous below with substantia gelatinosa Rolandi of spinal medulla.

Motor Nuclei.—(1) A nucleus placed close to medial side of upper sensory nucleus. (2) Cells in lateral part of grey matter of aquæductus cerebri (Sylvii); fibres from these cells (possibly sensory) form descending (mesencephalic) root, which enters pons, runs down along medial side of brachium conjunctivum, and joins fibres from pontine nucleus, and passes out with portio major.

Communications : Nuclei : fibres of opposite pyramidal tract to motor nuclei, from sensory nuclei to opposite lemniscus; from its sensory to its motor nuclei, constituting a short reflex. Connections with nuclei of other nerves. **Fibres :** from tractus spinalis to nucleus of facial.

Portio major, traced from pons, passes upwards, anteriorly and laterally, crosses upper border of petrous temporal, near apex, below attached margin of tentorium and sup. petrosal sinus, and enters concave border of semilunar ganglion. **Portio minor** accompanies major, on its medial side and then below it. It passes anteriorly and downwards below semilunar ganglion and mandibular nerve, which it joins just after its exit through foramen ovale.

Semilunar ganglion (Gasserian) lies in a cavity between layers of dura mater on trigeminal impression, near apex of petrous, and on cartilage filling foramen lacerum. Portio minor (motor root of V.) and greater superficial petrosal nerves are below it. Cavernous sinus and carotid artery are medial to it. Gyrus hippocampi is above it. Portio major (sensory root of V.) leaves its concave postero-superior margin. Ophthalmic, maxillary and mandibular nerves

leave its convex antero-inferior margin. *Arteries* from int. carotid, middle and accessory meningeal.

Ophthalmic nerve runs forwards in lateral wall of cavernous sinus, below 3rd and 4th, giving off *n. tentorii* to dura mater, and communicating with 3rd, 4th and 6th nerves and sympathetic; divides into lacrimal, frontal and naso-ciliary branches.

Lacrimal nerve enters orbit through lateral angle of sup. orbital fissure, above muscles; runs along upper border of rectus lateralis; *supplies* lacrimal gland, conjunctiva and skin of upper eyelid.

Frontal nerve enters orbit through sup. orbit. fissure; runs anteriorly above muscles, divides at variable point into two: (1) *supra-orbital* passes through supra-orbital notch, *supplies* skin and conjunctiva of upper eyelid, scalp as far as vertex, mucous membrane of frontal sinus; (2) *supra-trochlear* runs anteriorly and medially above trochlea of obliquus superior; escapes from orbit, $\frac{1}{2}$ inch from median plane; *supplies* skin of median part of forehead, root of nose, medial commissure of eyelids and adjoining conjunctiva.

Naso-ciliary nerve (Nasal) enters orbit through sup. orb. fissure, between heads of rectus lateralis, and between divisions of oculo-motor nerve; runs medially and anteriorly, having rectus and obliquus superior above it, optic nerve and rectus medialis below it; leaves orbit, as **ant. ethmoidal nerve**, through ant. ethmoidal foramen and enters cranial cavity at side of crista galli; runs forwards on lamina cribrosa of ethmoid and enters nasal cavity through nasal slit; runs along nasal surface of nasal bone; gives **medial internal nasal branches** to anterior part of septum and **lateral internal nasal branches** to ant. part of lateral wall of nose; and leaves nose, as **external nasal branch**, between nasal bone and lateral nasal cartilage, to supply skin of lower half of nose.

Branches of Naso-ciliary N. in Orbit.—(1) **Long** (sensory) root to ciliary ganglion, on lateral side of optic nerve. (2) As it crosses optic nerve it sends two **long ciliary nerves**, along op. nerve, to back of eyeball. (3) At medial side of orbit it sends **post. ethmoidal nerve**, through post. eth. foramen, to post. ethmoidal sinuses and sphenoidal sinus. (4) Near its exit from orbit it gives off **infra-trochlear nerve** which communicates with supra-trochlear and leaves orbit below pulley of obliquus superior, to supply skin of eyelids, root of nose, conjunctiva, lacrimal caruncle and sac.

Ciliary Ganglion.—Small ('size of pin's head'); lies at back of

orbit between optic nerve and rectus lateralis, anterior or lateral to ophthalmic artery. **Roots**: long, sensory from naso-ciliary; short, motor from inf. branch of oculo-motor. Sympathetic from plexus on int. carotid art. either independently or in company with long root. **Branches**: 15 to 20 **short ciliary** pass with optic nerve to back of eyeball, which they pierce, and, with long ciliary, are distributed within it.

Maxillary nerve (Sup. max. div. of V.) runs anteriorly from semilunar ganglion, along infero-lateral border of cavernous sinus; passes through for. rotundum and upper part of pterygo-palatine fossa, pterygo-maxillary fissure and infra-temporal fossa; enters orbit through inf. orbital fissure (spheno-maxillary), where its name is changed to **infra-orbital**, which traverses infra-orbital groove, canal and foramen, accompanied by infra-orbital vessels, and ends on face by dividing, under cover of caput infra-orbitale (levator labii superioris) of quadratus lab. superioris, into branches for skin and conjunctiva of lower eyelid, skin of side of nose, cheek, upper lip and gums.

Branches.—(I.) In cranial cavity: *meningeal* branch to dura mater.

(II.) In pterygo-palatine (spheno-maxillary) fossa: two **spheno-palatine nerves** descend to spheno-palatine ganglion.

(III.) In infra-temporal fossa: **zygomatic n.** (temporo-malar or orbital) passes through inf. orb. fissure, and along lateral wall of orbit, between bone and periosteum; enters for. zygomaticum in zygomatic (malar) bone, divides in substance of bone into *zygomatico-facial* and *zygomatico-temporal branches*, which emerge through foramina of corresponding names on its facial and temporal surfaces. Z.-facial supplies skin in malar region; z.-temporal pierces temporal fascia near zygomatic bone and supplies skin of temporal region. (It may divide in orbit and enter separate foramina on zygomatic bone.) **Posterior superior alveolar branches** (post. sup. dental) arise just before nerve enters orbit, descend over infra-temporal surface of maxilla, supply gum and perforate maxilla to reach molar teeth.

(IV.) In infra-orbital groove and canal: **middle and anterior superior alveolar branches** descend in wall of maxillary sinus and supply gums, mucous membrane of sinus; premolar teeth (from middle branch), canine and incisor teeth and mucous membrane of nose (from anterior branch).

(V.) On face: *palpebral, nasal and labial*, as above.

Spheno-palatine ganglion (Meckel's) is suspended from maxillary nerve by spheno-palatine nerves, in upper part of

pterygo-palatine fossa, lateral to spheno-palatine foramen, surrounded by fat and branches of int. maxillary art. and their companion veins.

Roots.—Sensory: *spheno-palatine nerves*. Motor and sympathetic *n. canalis pterygoidei* (Vidian nerve), formed, in fibro-cartilage filling for. lacerum, by union of greater superficial petrosal branch of facial and (great) deep petrosal branch from plexus around int. carotid artery; runs anteriorly through pterygoid canal (Vidian) and joins ganglion. **Branches.**—Orbital supply periosteum of orbit. Nasal pass through spheno-palatine foramen and supply upper and posterior part of nasal cavity, chiefly on lateral wall. **Naso-palatine** passes through spheno-pal. for., crosses roof of nasal cavity, descends along septum to palate, enters roof of mouth through foramen of Scarpa; supplies mucous membrane of nose, gums and hard palate. **Anterior palatine** descends through greater palatine canal, giving off *inferior nasal* branch to lower and posterior part of nose; ends by supplying soft and hard palate and gums. *Middle* and *posterior palatine* spring from ant. palatine and descend through canals in pyramid of palatine bone and supply soft palate, uvula and palatine tonsil. **Pharyngeal** passes posteriorly through pharyngeal canal to roof of pharynx.

Mandibular Nerve (Inf. max. div. of V.).—Two roots: sensory from semilunar ganglion, motor from mesencephalon and pons. They emerge from skull through foramen ovale and unite below it to form single trunk, which lies $1\frac{1}{2}$ inches medial to tubercle at root of zygoma. Tensor veli palatini is *medial* to it and separates it from auditory tube; pterygoideus externus is *lateral*, pterygoideus internus is *anterior*, mid. meningeal art. is *postero-lateral*. It very soon breaks up into 2 divisions.

Branches of Undivided Trunk.—*V. spinosus* (recurrent) accompanies mid. meningeal artery through for. spinosum to dura mater. *V. pterygoideus internus* passes anteriorly and downwards into pterygoideus internus; otic ganglion is associated with it.

Anterior division runs down under cover of pterygoideus externus and divides into branches: *n. pterygoideus externus* sinks at once into that muscle; *n. massetericus* passes laterally above pterygoideus externus and through mandibular notch, behind temporal muscle; gives branch to mandibular joint and enters deep surface of masseter, near posterior border; *anterior* and *posterior deep temporals* appear above pter. externus and sink into temporal muscle; *buccinator nerve* (long buccal) passes laterally between heads

of pterygoideus externus and sends branch up over its upper head to temporal muscle; then downwards and anteriorly, over lower head of pterygoideus externus, under cover of temporal muscle, coronoid process and masseter, frequently piercing temporal muscle; reaches surface of buccinator, and supplies skin and mucous membrane of cheek.

Posterior Division.—Larger: extends downwards a short distance between pterygoideus externus and tensor veli palatini, gives off auriculo-temporal, and divides into lingual and inferior alveolar.

Auriculo-temporal n. arises by 2 roots, which embrace middle meningeal artery; passes posteriorly, under cover of pterygoideus externus, and between neck of mandible and spheno-mandibular lig.; ascends behind mandibular joint, under cover of parotid; crosses zygoma in front of ear, divides into 2 superficial temporal branches. *Branches*: to upper part of lateral surface of auricle, to upper parts of meatus and tympanic membrane, to mandibular joint, to parotid gland; to skin of side of head, almost to vertex. *Communications*: by its roots with otic ganglion, to facial in parotid, with facial and zygomatico-temporal on temple.

Lingual n. runs downwards and forwards, anterior to alveolar n. (inf. dental), first between pterygoideus ext. and int., next between mandible and pterygoideus internus, next under cover of mucous membrane of mouth, upon superior constrictor and stylo-glossus. It then runs forwards between mylo-hyoid and hyoglossus, and lastly between sub-lingual gland and genio-glossus, crossing submaxillary duct; and supplies gums and anterior $\frac{2}{3}$ of tongue. (See also p. 225.)

Inferior alveolar n. (inf. dental) descends first between pterygoideus externus and tensor v. palatini, next between mandible and spheno-mandibular ligament, accompanied by alveolar vessels; enters mandibular foramen and runs through mandibular canal. *Branches*: (1) to teeth and gums of mandible. (2) *N. mylohyoides* arises just above mandibular foramen; is accompanied by mylo-hyoid vessels; pierces spheno-mandibular ligament, runs along mylo-hyoid groove of mandible, lying upon mylo-hyoid muscle; supplies mylo-hyoid and ant. belly of digastric. (3) *Mental n.* emerges from mental foramen, opposite 2nd premolar; supplies skin of chin, skin and mucous membrane of lower lip, and gums.

Otic ganglion lies below for. ovale, between mandibular nerve and tensor v. palatini, which separates it from auditory tube, some

distance anterior to mid. meningeal art., posterior to pterygoideus internus, upon origin of its nerve. **Roots** : from nerve to pterygoideus internus (motor root) ; lesser superficial petrosal n., containing fibres of glosso-pharyngeal and of facial, enters it (sensory root) ; sympathetic root from plexus on mid. meningeal art. **Communications** to pterygoid (Vidian) nerve, to chorda tympani ; to auriculo-temporal, for parotid gland, and probably derived from glosso-pharyngeal. **Branches** to tensor veli palatini, tensor tympani.

Submaxillary ganglion, lies on hyoglossus, above submaxillary duct and deep part of gland, suspended by 2 or 3 trunks from lingual nerve. (See also p. 226.)

Abducent Nerve (6th). — *Motor* to rectus lateralis of orbit. Emerges at lower border of pons, at upper end of lateral side of pyramid ; ascends upon clivus of sphenoid, anterior to pons ; pierces dura mater, notches side of base of dorsum sellæ, enters cavernous sinus ; runs anteriorly on lateral side of int. carotid artery ; enters orbit through sup. orbital fissure, between heads of rectus lateralis, below oculo-motor and naso-ciliary nerves, above ophthalmic vein ; runs forwards along ocular surface of rectus lateralis and enters its substance.

Nucleus lies under grey matter low down in pontine part of floor of 4th ventricle, lateral to medial (posterior) longitudinal bundle, in concavity of loop of facial nerve. **Fibres** pass ventrally and downwards through whole substance of pons, along medial side of superior olivary nucleus, through lateral edge of lemniscus and pyramidal tract.

Communications. — **Nucleus** : from opposite motor area ; to medial longitudinal bundle (*a*) to connect it with other nuclei, (*b*) to cross and join fibres of 3rd going to rectus medialis of opposite side, or to end in relation to the cells from which these fibres arise ; from superior olivary nucleus. **Nerve** from sympathetic and from ophthalmic nerve in cavernous sinus.

Facial Nerve (7th). — *Motor* mainly to muscles of face and scalp, *sensory* (taste) to tongue.

Motor root of facial nerve emerges at lower border of pons, at upper end of medial side of restiform body ; runs anteriorly and laterally, enters int. acoustic meatus in company with acoustic n. and n. intermedius. At bottom of meatus, n. intermedius is incorporated with it, and it enters canalis n. facialis (aqueduct of Fallopius), which conducts it laterally over vestibule to antero-superior part of medial wall of tympanum, then posteriorly along junction of medial wall and roof, then downwards, behind tympanum, to stylo-mastoid foramen.

There it turns forwards, lateral to styloid process, which separates it from int. jugular vein; enters parotid gland, breaks up into branches which lie superficial to posterior facial vein (temporo-maxillary) and ext. carotid artery, and radiate from anterior, inferior and superior borders of gland. Its first bend is called *geniculum n. facialis* (genu), and on it is placed the *ganglion geniculi* (geniculate).

Branches after Exit from Skull.—Branches to posterior belly of digastric and stylo-hyoid. **Posterior auricular n.** turns upwards between mastoid process and external meatus, supplies auricularis posterior (retrahens), intrinsic muscles of ear, occipital belly of epicranii. In parotid gland, facial nerve receives *communications* from great auricular and auriculo-temporal, and breaks up into branches: **temporal**, to auricularis anterior and superior and facial muscles above orbit; **zygomatic**, to facial muscles below orbit; **buccal**, to buccinator and muscles at side of mouth; **ramus marginalis mandibulæ**, to muscles of chin and lower lip; **ramus colli**, to platysma in neck and sends up twigs to muscles of lower lip.

Branches in Facial Canal.—(1) **Greater superficial petrosal** arises from gang. geniculi, emerges through hiatus canalis facialis (Fallopii), runs medially and anteriorly, over anterior surface of petrous temporal and below semilunar (Gasserian) ganglion, to fibro-cartilage filling for. lacerum. There the (great) deep petrosal from carotid sympathetic plexus joins it to form **n. canalis pterygoidei** (Vidian), which runs through pterygoid canal to pterygo-palatine (spheno-maxillary) fossa, to end in spheno-palatine ganglion (Meckel's). (2) A filament, called *ext. superficial petrosal nerve*, from sympathetic around mid. meningeal art. passes through hiatus to join ganglion geniculi. (3) A branch from geniculum (not from ganglion) joins a branch from tympanic plexus to form lesser superficial petrosal nerve in substance of petrous temporal. (4) **Nerve to stapedius** is given off behind tympanic cavity. (5) **Chorda tympani** is given off a short distance above stylo-mastoid foramen; ascends and enters tympanum through posterior wall; runs anteriorly, opposite upper edge of tympanic membrane, on medial side of neck of malleus; leaves in front of upper part of membrane, appears at medial end of petro-tympanic fissure (Glaserian); runs downwards and forwards on medial side of angular spine of sphenoid and on medial side of pterygoideus externus, where it receives branch from otic ganglion, and joins lingual. Supplies anterior $\frac{2}{3}$ of tongue (sense of taste) and submaxillary and sublingual glands (secretory) through lingual n. and submaxillary ganglion. (6) A *communicating* twig from facial to auricular branch of vagus is given off at same level as chorda.

Nucleus of motor root lies low down in pons, on medial side of tractus spinalis (spinal root of V.), on dorsal surface of corpus trapezoidum, but partly separated from it by sup. olivary nucleus. **Fibres** pass dorsally and medially to floor of 4th ventricle, turn sharply upwards for 5 mm., under ependyma, along dorso-medial side of nucleus of abducent; turn sharply laterally, and then ventrally, downwards and laterally, through whole substance of pons, between its own nucleus medially and tractus spinalis laterally; emerge at lower border of pons.

Connections — **Nucleus**: fibres from opposite motor area, fibres from tractus spinalis, from corpus trapezoidum. To other nuclei through medial longitudinal bundle. **Fibres**: from oculo-motor nucleus through med. longit. bundle to join fibres going to orbicularis oculi, corrugator supercilii, frontalis; from hypoglossal nucleus through med. long. bundle to join fibres going to orbicularis oris.

Nervus intermedius (Pars intermedia) is sensory root of facial. Its peripheral ganglion is the **g. geniculi**, cells of which send peripheral branches into chorda tympani and greater superficial petrosal nerve, and their central branches run inwards in the facial nerve and detach themselves at bottom of internal meatus to form n. intermedius. *N. intermedius* communicates with vestibular nerve, accompanies facial to brain, enters upper end of medulla between facial and acoustic, passes dorsally and medially through or dorsal to tractus spinalis (of V.), ends in cells of upper end of tractus solitarius, i.e. sensory nucleus of glosso-pharyngeal. From these cells fibres cross to opposite lemniscus, and some enter medial longitudinal bundle to end in nuclei of other nerves.

Acoustic Nerve 8th, Auditory. — Special sense: hearing, equilibrium and sense of localisation of position. Consists of 2 parts, vestibular and cochlear. Peripheral ganglion of vestibular is **g. vestibulare**, which lies in int. acoustic meatus. Its peripheral fibres form **vestibular nerve**, which communicates with n. intermedius and ganglion geniculi, pierces bottom of meatus, supplies utricle and superior and external semicircular ducts. Peripheral ganglion of cochlear part is **g. spirale**, which lies in spiral canal of modiolus. Its peripheral fibres supply organ of Corti, saccule, post. semicircular duct. Central fibres form **cochlear nerve**, and pass inwards through bottom of meatus, join central fibres of vestibular ganglion in meatus to form **acoustic nerve**, which runs posteriorly and medially to lower border of pons, at upper end of restiform body, lateral to facial n.; and there it separates into a *vestibular* and a *cochlear root*.

Vestibular root passes dorsally on medial side of restiform

between it and tractus spinalis of V., and its fibres divide into two: (1) *descending branches* partly end in "principal" or dorsal nucleus, situated under area acustica of 4th ventricle, and partly run down along medial side of restiform body as far as level of decussation of lemniscus, and end around cells mingled with them; (2) *ascending fibres* end in nuclei of Deiters and Bechterew (lateral and superior), situated in lateral angle of 4th ventricle, at medial side of restiform body, and some pass by restiform body to nucleus fastigii, n. globosus and n. emboliformis of opposite side, or through them to cerebellar cortex. These cerebellar nuclei lie in white centre of vermis.

Further Connections.—(1) Fibres pass to and fro in restiform body between nuclei of vestibular root and the cerebellar nuclei of opposite side. (2) From Deiters and Bechterew, fibres join opposite lemniscus (medial fillet), and join medial (posterior) longitudinal bundle, split and send branches upwards in it to oculo-motor nuclei, downwards in it and in fasciculus anterior proprius (ant. basis bundle) to end round motor cells of spinal medulla. (3) Vestibulo-spinal tract arises in nuclei of Deiters and Bechterew, descends through lateral part of medulla oblongata and of anterior funiculus (column) of medulla spinalis, ends round motor cells, reaching as far as lumbar region.

Cochlear root curves round lateral side of restiform body. Its fibres end mainly in 2 nuclei: a *lateral* placed on lateral side of restiform body, under cochlear root; a *ventral*, in front of restiform body, in angle between cochlear and vestibular roots. [Some fibres pass directly into medullary striæ (striæ acusticæ).]

Further connections are established through and with the following:—*Striæ medullares (acusticæ)* are transverse fibres, seen under ependyma, at junction of pontine and medullary parts of floor of 4th ventricle. *Corpus trapezoideum* is a group of transverse fibres in lower part of pons, between its dorsal and basilar divisions; *nucleus corp. trap.* is a group of cells in its substance. *Sup. olivary nucleus* is placed on dorsal surface of corp. trapezoideum and partly imbedded in it. *Lemniscus lateralis* (lateral fillet) is a broad flat band of fibres which emerges from groove between pons and brachium conjunctivum (sup. cer. ped.); lies on lateral side of brachium, disappears above, under inf. corp. quad., brachium inferius and corpus geniculatum mediale; *nucleus lem. lat.* is a group of cells placed in it at its beginning. *Acoustic radiation* consists of fibres which arise in medial geniculate body, enter most posterior part of internal capsule, thence pass laterally above roof of inferior (descending) horn of lateral ventricle to end in acoustic centres. *Acoustic centres* are in the middle of superior temporal gyrus and in adjoining gyri on insular surface.

Fibres of cochlear root end round cells of cochlear nuclei and new fibres arise:—(1) Fibres from ventral nucleus and a few from lateral nucleus, pass medially through vestibular root and form corpus trapezoideum. Fibres of corpus trapezoideum cross median plane,

decussating with fellows, reach lateral part of pons, turn upwards and dorsally and become lateral lemniscus; some of the fibres end in, and new fibres arise from, nuclei of corp. trap., sup. olive, lat. lemniscus.

(2) Most fibres of lateral nucleus, having been joined by fibres from cochlear root directly, pass medially as *striae medullares* (*acusticae*), dip ventrally through medulla, at median plane at lower border of pons, cross and join lateral lemniscus. Fibres of lemniscus end in medial geniculate body, both inf. corp. quadrigemina, and a few in superior corp. quad.; those to geniculate body are all from opposite side, some of those to inf. corpora are from same side. Fibres from medial geniculate body proceed as acoustic radiation to acoustic centres.

Fibres from sup. olivary nucleus, called its *pedicle*, pass dorsally to nucleus of abducent nerve, and to medial longitudinal bundle, to be carried in it to nuclei of oculo-motor and trochlear.

Résumé of neurons connected with conduction of sound: (1) bipolar cells of ganglion spirale and their processes (*a*) to organ of Corti, (*b*) to form cochlear nerve; (2) neurons of lateral and ventral cochlear nuclei; (3) neurons of sup. olivary nucleus, and nuclei of corp. trapezoideum and lemniscus lateralis; (4) neurons of medial geniculate body.

Glosso-pharyngeal Nerve (9th). *Sensory* to tongue and pharynx; *motor* to stylo-pharyngeus. Roots emerge from medulla oblongata a little dorsal to olive, combine to form single trunk, which passes laterally, anterior to flocculus, on post. surface of jugular tubercle; downwards through jugular foramen with vagus and accessory, but in separate sheath of dura; passes forwards between internal jugular vein and internal carotid artery; descends superficial to int. carotid, deep to ext. carotid, styloid process and its muscles; reaches lower border of stylo-pharyngeus, supplies it and turns forwards superficial to it, and comes into relation with tongue under cover of hyoglossus; gives sensory branches to pharynx, palatine tonsil and post. $\frac{1}{3}$ of tongue. (See also p. 226.)

Motor nucleus is the *n. ambiguus*, a column of cells in medulla oblongata, midway between olivary nucleus and tractus spinalis of V, and continuous below with anterior grey column of spinal medulla. Motor fibres pass dorsally and then laterally to join with sensory fibres.

Peripheral ganglia are **g. superius** (jugular) and **g. petrosum**, placed on nerve in jugular foramen. A few sensory fibres end in nucleus *like cerneræ* (see *n. vagus*), but most join **tractus solitarius**, a longitudinal strand placed medial and ventral to descending fibres of vestibular root, and extending from upper end of medulla oblongata down into medulla spinalis as far as level of 4th cervical nerve. Its

fibres end in a nucleus placed alongside. *Communications* (see *n. vagus*). Motor and sensory fibres, traced outwards, pass through tractus spinalis (spinal root of V.) and emerge through upward prolongation of postero-lateral sulcus, a little dorsal to olive.

Branches.—Ganglion superius gives none. Ganglion petrosum communicates with sup. cervical sympathetic gangl., auricular branch and ganglion nodosum (of trunk) of vagus; gives off *n. tympanicus*, which enters tympanum through foramen between jugular fossa and carotid canal, breaks up on promontory into plexus, which is joined by sup. and inf. carotico-tympanic branches from carotid sympathetic plexus, and gives branches to mucous membrane of tympanum, mastoid cells, auditory tube. A branch arises from tympanic plexus, enters petrous temporal, is joined there by branch from facial to form **lesser superficial petrosal nerve**, which emerges through opening below hiatus canalis facialis (Fallopian), runs forwards and downwards between petrous temporal and great wing of sphenoid, or through special aperture (canaliculus innominatus), or through for. ovale, and ends in otic ganglion. In the neck, **ramus stylo-pharyngeus** supplies that muscle and passes through it to pharynx. *R. pharyngei* join with pharyngeal branches of vagus and sympathetic and supply mucous membrane of pharynx. Terminal branches—*r. linguales* and *tonsillares*—supply post. $\frac{1}{3}$ of tongue (taste and common sensation), palatine tonsil, soft palate, glosso-epiglottic folds, and front of epiglottis.

Vagus Nerve (10th).—*Sensory* and *motor*; widespread distribution. Roots combined in one trunk.

Motor nuclei are *n. ambiguus* (see glosso-pharyngeal) and *n. dorsalis*. **Peripheral ganglia** are *g. jugulare* (g. of root) placed on nerve in jugular foramen, and *g. nodosum*, situated below jugular foramen. A few sensory fibres join tractus solitarius (see *n. glosso-phar.*), but most end in *dorsal nucleus*, which is both motor and sensory and lies under ala cinerea (trigonum vagi) in upper part of medulla oblongata, and dorsal to nucleus of hypoglossal in lower part, on lateral aspect of central canal. The fibres which correspond peripherally to auricular branch of vagus end in nucleus of tractus spinalis of V. **Communications**: fibres of opposite pyramidal tract end in motor nucleus. Fibres from sensory nuclei join opposite lemniscus, and some join medial longitudinal bundle to connect with other nuclei. Motor fibres run dorsally and laterally and join sensory fibres, and together they traverse tractus spinalis and emerge through upper part of postero-lateral sulcus, below glosso-pharyngeal. Motor fibres in vagus from nucleus ambiguus go to pharynx and larynx; those from dorsal nucleus go to heart, œsophagus, stomach, trachea and bronchi.

Vagus nerve trunk, formed by union of fila radicularia

(rootlets) which emerge from side of medulla oblongata, passes laterally in front of flocculus, behind jugular tubercle; descends through jugular foramen in same sheath of dura as accessory n.; enters and descends through carotid sheath, behind and between artery and vein. Below base of skull the hypoglossal nerve passes laterally behind vagus, turns forwards and is adherent to its lateral side, and, lastly, crosses medially in front of it.

Right vagus, at root of neck, crosses subclavian art. to lie behind innominate vein; enters thorax on right side of innominate art., passes downwards and backwards by side of trachea, behind innominate vein and vena cava, to back of root of lung. In sup. mediastinum, right pleura covers it above, but is separated from it below by arch of azygos vein. At root of lung it breaks up into **post pulmonary plexus**, from which one or more cords pass across vena azygos to œsophagus and break up into *post. œsophageal plexus*. A single trunk emerges from this and descends through hiatus œsophageus of diaphragm, to break up into *post. gastric plexus* on postero-inferior surface of stomach. **Left vagus** passes behind innominate vein at root of neck, descends into thorax between left common carotid and subclavian arteries. It is covered by left pleura, and is crossed from behind forwards by phrenic. It crosses arch of aorta, and breaks up into post. pulmonary plexus on back of root of left lung. From this, one or more cords pass anterior to descending aorta to form *ant. œsophageal plexus*, and a cord runs from it to break up into *anterior gastric plexus*.

Branches.—Ganglion jugulare communicates with sup. cervical ganglion and accessory nerve, and gives off branches: (1) *meningeal*, to dura mater; (2) *auricular* enters foramen in jugular fossa, emerges through tympanomastoid (auricular) fissure, supplies skin of exterior and interior of external meatus posteriorly. G. nodosum communicates with sup. cervical ganglion, hypoglossal, 1st cervical n.; receives internal branch (cerebral roots) of accessory n., which gives to vagus the inhibitory fibres for heart, and assists vagus in the motor supply of pharynx, larynx, œsophagus, stomach, intestines and respiratory organs.

G. nodosum gives off branches: (1) **Pharyngeal** runs downwards and forwards, between ext. and int. carotids, to middle constrictor, where it breaks up and joins pharyngeal branches of glosso-pharyngeal and sympathetic to form

pharyngeal plexus, from which branches pierce constrictors, supply mucous membrane and muscles of pharynx except stylo-pharyngeus, and muscles of palate except tensor; a small *lingual branch* from the plexus joins hypoglossal.

(2) **Superior laryngeal n.** descends between int. carotid art. and middle constrictor, and divides into two: (a) *ramus internus (int. laryngeal)* passes from middle constrictor on to thyreo-hyoid membrane, pierces it in company with sup. laryngeal vessels, supplies mucous membrane of larynx, epiglottis, base of tongue; (b) *r. externus (ext. laryngeal)* descends upon inf. constrictor, helps to supply it, and ends in crico-thyreoides.

Superior cardiac rami arise from vagus in neck, one high up, the other low down. On right side, they pass behind subclavian artery and run along trachea to deep cardiac plexus. On left side, the upper one runs along trachea to deep plexus; lower one runs in front of vagus, across aortic arch, to superficial cardiac plexus.

Recurrent nerve, on right side, arises at root of neck, as vagus crosses subclavian artery; turns upwards and medially behind subclavian and common carotid arteries; ascends in groove between trachea and œsophagus; passes under cover of lower border of inf. constrictor, receives the name of *inferior laryngeal* and enters larynx. *On left side*, it arises as vagus crosses aortic arch; hooks round aorta, at lateral side of attachment of lig. arteriosum, and ascends in groove between trachea and œsophagus. *Recurrent nerves* give the following branches: (1) *inferior cardiac* pass to deep cardiac plexus; (2) *muscular* to trachealis, œsophagus, inferior constrictor, laryngeal muscles except crico-thyroid.

Cardiac branches arise from trunk of right vagus in thorax as well as from recurrent nerve.

Anterior bronchial rami arise from vagus above root of lung and are joined by branches from deep cardiac plexus (and on left side from superficial also) to form *ant. pulmonary plexus*, which supplies structures of root anteriorly. *Post. pulmonary plexus* is formed by trunk of vagus breaking up into **posterior bronchial rami**. It is joined by branches from 2nd, 3rd and 4th thoracic ganglia of sympathetic, and sends branches into lung.

Esophageal plexuses are formed in sup. mediastinum by branches from right vagus and left recurrent n.; in post. mediastinum by cords of vagi coming out of post. pulmonary

plexuses, and by branches of splanchnic nerves. They supply œsophagus and back of pericardium. *Ant. gastric plexus*, formed by left vagus, supplies stomach and sends branches to hepatic plexus. *Post. gastric plexus*, formed by right vagus, supplies stomach, and sends branches to cœliac, splenic and renal plexuses.

Accessory Nerve (11th ; Spinal accessory).—Motor. Consists of 2 portions. A *cerebral portion*, accessory to vagus, from medulla oblongata, to supply musculature of great part of alimentary and respiratory tracts ; a *spinal portion*, from spinal medulla, to supply sterno-mastoid and trapezius. Fila radicularia (rootlets) of **spinal portion** emerge from side of spinal medulla, between ant. and post. roots of cervical nerves ; unite to form 1 or 2 cords which ascend through foramen magnum, and turn laterally to jugular foramen. Fila of **cerebral portion** emerge from side of medulla oblongata, below vagus, in line with post. roots of cervical nerves ; run laterally to jugular foramen, and join spinal portion.

The accessory nerve, so formed, pierces dura, and enters jugular foramen in company with vagus.

In jugular foramen it divides into two : 1. **Ramus internus** (cerebral fibres), which communicates with ganglion jugulare, and joins vagus at ganglion nodosum and is distributed through vagus (q.v.). 2. **Ramus externus** (comprising the spinal fibres and commonly referred to, in neck, as *accessory nerve*) descends between carotid artery and internal jugular vein ; turns laterally and posteriorly, superficial or deep to vein, in front of transverse process of atlas, deep to styloid process, posterior belly of digastric and occipital art. ; crosses upper angle of anterior triangle of neck, accompanied by branch of occipital artery ; enters sterno-mastoid, supplies it, communicates with 2nd cervical ; reappears above middle of posterior border of sterno-mastoid ; crosses posterior triangle obliquely, downwards and posteriorly ; communicates with 3rd and 4th cervical, and disappears under cover of trapezius, in which it ends.

Nucleus of Spinal Portion.—Cells in ant. column (horn) of spinal medulla, posterior to cells of origin of motor roots of upper 5 cervical nerves. **Fibres** pass dorsally through ant. column ; appear in bay between ant. and post. columns (horns) ; turn laterally through fasciculus lateralis proprius (lateral basis bundle) (cerebral

spinalis lateralis (crossed pyramidal), and f. cerebello-spinalis (direct cerebellar); appear at surface between ant. and post. roots of cervical nerves, behind lig. denticulatum. **Nucleus of Cerebral Portion** is n. ambiguus (see glosso-pharyngeal nerve). **Fibres** pass laterally, on ventral side of tractus spinalis (spinal root of V.), and appear at surface, below vagus.

Connections of Nuclei.—With opposite motor area, with other nuclei through medial longitudinal bundle and fasc. anterior proprius (ant. basis bundle). Some fibres of posterior nerve-roots of cervical nerves end in spinal nucleus.

Hypoglossal Nerve (12th).—*Motor* to muscles of tongue. Fila emerge from medulla oblongata, between olive and pyramid, and form two bundles, which pierce dura mater separately and unite in hypoglossal canal (ant. condyloid foramen). Trunk enters neck; lies at first medial to int. jugular vein and carotid artery; passes laterally and then forwards between them, making $\frac{1}{2}$ -spiral twist around vagus; descends under cover of styloid process and post. belly of digastric; at lower border of digastric it hooks round occipital artery, turns forwards over int. and ext. carotids, disappears again under cover of digastric and stylo-hyoid; proceeds towards tongue between mylo-hyoid and hyoglossus. (See also pp. 221, 226.)

Branches.—*Meningeal*, to dura mater. *R. descendens* (Descendens hypoglossi) arises opposite int. carotid, descends in front of carotid sheath or within it; is joined by r. descendens cervicalis from 2nd and 3rd cervical nerves, and they form loop called *ansa hypoglossi*, from which branches go to omo-hyoid, sterno-hyoid, sterno-thyreoid. *R. thyro-hyoides* descends to that muscle. *Rami linguales* supply genio-hyoid, stylo-glossus, hyo-glossus, genio-glossus and intrinsic muscles of tongue.

Nucleus extends nearly whole length of medulla oblongata; is continuous with base of ant. column (horn) of medulla spinalis; lies under trigonum n. hypoglossi in upper part of medulla oblongata, and in ventral wall of central canal in lower part. **Connections**: with opposite motor area; with opposite nucleus by commissural fibres; with other nuclei, through medial long. bundle and fasc. ant. proprius. Some fibres ascend and join those of facial going to orbicularis oris. **Fibres** pass ventrally through whole thickness of medulla between substantia reticularis grisea and alba, and emerge between olive and pyramid.

Communications of Nerve Trunk.—(1) With g. nodosum.

(2) Sup. cervical ganglion. (3) Branch from loop between 1st and 2nd cervical nerves joins it and leaves it as descendens hypoglossi and nerves to thyreo-hyoid and genio-hyoid; this communication may partly join vagus, which, in that case, gives off the descending branch. (4) With pharyngeal plexus by lingual branch of vagus. (5) With lingual at ant. border of hyoglossus.

SYSTEMA NERVORUM SYMPATHICUM

Sympathetic nervous system consists of two trunks with their ganglia (gangliated cords), and numerous plexuses made up of their branches and containing subsidiary ganglia. The trunks give grey rami communicantes to all spinal nerves, and receive white rami communicantes from some spinal nerves (from 2nd thoracic to 2nd lumbar inclusive). White r. communicantes from 3rd and 4th sacral nerves join pelvic plexuses.

TRUNCUS SYMPATHICUS

Sympathetic trunk begins in superior cervical ganglion, below base of skull; descends *posterior to* internal and common carotids, *anterior to* cervical transverse processes and longus capitis (rectus major and colli, *medial to* vagus, and is crossed, either in front or behind, by inf. thyreoid art., opposite cricoid cartilage and 6th vertebra.

Enters thorax in front of neck of 1st rib, medial to superior intercostal artery and 1st thoracic n., behind apex of pleura; descends *anterior to* neck of 2nd rib, heads of next 3 or 4, lig. radiata (stellate) of next 2 or 3, and finally on sides of bodies of lower thoracic vertebrae; in intervals between ribs and on the vertebrae it is anterior to intercostal vessels; and it is *posterior to* pleura throughout.

Enters abdomen behind medial lumbo-costal arch (int. arcuate lig.); descends *anterior to* lumbar arteries, along interval between ant. border of psoas major and the vertebrae. **On left side**, it is *posterior to* renal vessels, pancreas, end of duodenum, spermatic vessels, colic and sigmoid branches of int. mesenteric art., common iliac vessels. **On right side**, it is *posterior to* renal artery, vena cava, common iliac artery.

Enters pelvis in front of ala of sacrum; descends *medial to* sacral foramina, *anterior to* branches of mid. sacral art. passing to foramina, *posterior to* pelvic colon or ileum above, but separated by peritoneum from them; behind rectum below. Ends by joining its fellow in *ganglion impar* on pelvic surface of coccyx, behind rectum.

GANGLIA TRUNCI SYMPATHICI

Superior Cervical Ganglion, 1 inch or more in length, lies below base of skull, between int. carotid art. and longus capitis (rectus cap. ant. major), opposite 2nd and 3rd vertebræ. **Communications**: with glosso-pharyngeal, vagus and hypoglossal nerves. **Branches**: (1) *Grey rami communicantes* to upper 4 cervical nerves. (2) *Nn. carotici interni* are prolonged on to int. carotid artery, and form internal carotid plexus. *Internal carotid plexus* sends carotico-tympanic branches, through the bone, to tympanic plexus; gives off deep petrosal, which joins greater superficial to form pterygoid n. (Vidian); supplies hypophysis (pituitary body); sends a root to ciliary ganglion either independently through sup. orbital fissure or with nasociliary; and is continued on to branches of int. carotid. Communicates with oculo-motor, trochlear, abducent and ophthalmic nerves and semilunar ganglion (Gasserian). (A concentration of int. carotid plexus where the artery bends forwards at side of sphenoid has been called cavernous plexus.) (3). *Nn. carotici externi* form plexuses on ext. carotid and its branches; plexus on ext. maxillary art. gives a root to submaxillary ganglion; plexus on mid. meningeal gives fibres to otic ganglion. (4) *Rami laryngo-pharyngei* join pharyngeal branches of 9th, 10th and ext. laryngeal nerves on wall of pharynx. (5) *N. cardiacus superior* descends behind carotid artery, in front of inf. thyroid; on right side it crosses subclavian art. and descends along trachea to deep cardiac plexus; on left side it descends between carotid and subclavian arteries, crosses aortic arch and ends in superficial cardiac plexus. On both sides it communicates in neck with other cardiac nerves and with ext. and recurrent laryngeal.

Middle Cervical Ganglion.—Small; may be absent. Lies on inferior thyroid artery, opposite 6th vertebra. **Branches**: (1) *Grey rami communicantes* to 5th and 6th cervical nerves; (2) *thyroid branches* accompany inf. thyroid art. to thyroid gland; (3) *n. cardiacus medius*, on right side, accompanies superior nerve to deep cardiac plexus; on left side, accompanies superior nerve as far as aorta, where it dips behind arch to reach deep plexus; (4) *ansa subclavia* (Vicussemii) is a branch which descends in front of subclavian artery, giving twigs to it and its branches, turns round it to ascend behind it and join inferior cervical ganglion. When ganglion is absent the branches arise from trunk.

Inferior Cervical Ganglion.—Irregular in shape. Lies between 7th cervical transverse process and neck of 1st rib, between vertebral art. and 8th cervical nerve. May be fused with 1st thoracic. **Branches**: (1) *grey rami communicantes* to 7th and 8th c. nerves; (2) *vertebral plexus* accompanies vertebral art. to brain, and gives plexuses to its branches; (3) *n. cardiacus inferior* accompanies other cardiac nerves to deep plexus. (See also p. 215.)

Thoracic Ganglia.—Typically 12 in number, but often reduced by fusion of neighbouring ganglia. They send *grey rami communicantes* posteriorly and laterally to intercostal nerves, and all except 1st receive *white r. communicantes* from intercostals. Upper 5 ganglia send branches to aorta, vertebræ and their ligaments; 2nd, 3rd, 4th send branches to post. pulmonary plexus. **Greater splanchnic n.** arises from 5th to 9th ganglia; descends under cover of pleura, upon intercostal arteries and bodies of vertebræ, close to lateral side of vena azygos on right side, of v. hemiazygos on left side; gives branches to descending aorta and œsophagus; pierces crus of diaphragm, and ends in cœliac ganglion; *splanchnic ganglion* is placed on it near exit from thorax, and gives branches to aorta and œsophagus. **Lesser splanchnic n.** arises from 10th and 11th ganglia, pierces crus, and ends in cœliac ganglion. *N. splanchnicus imus* arises from last ganglion, pierces crus, and ends in renal plexus.

Lumbar Ganglia.—Irregular in number—4 to 8. Send *grey rami communicantes* to lumbar nerves; these accompany lumbar vessels, deep to psoas major. Receive *white r. communicantes* from 1st and 2nd lumbar nerves. Send irregular branches to aortic and hypogastric plexuses.

Sacral Ganglia.—Usually 4. Send *grey r. communicantes* to sacral and coccygeal nerves, branches to pelvic plexuses, and branches to form plexus around middle sacral artery. (White r. communicantes arise from 3rd and 4th sacral nerves, but they join pelvic plexuses.)

THE LARGE SYMPATHETIC PLEXUSES

Cardiac Plexus consists of a superficial and a deep part.

Superficial cardiac plexus lies in concavity of aortic arch, in front of bifurcation of pulmonary artery. Formed by superior cervical cardiac branch of left sympathetic and inferior cervical cardiac branch of left vagus. *Cardiac ganglion* (Wrisberg) is placed on their union. **Branches:** (1) to left $\frac{1}{2}$ of deep plexus; (2) to left anterior pulmonary plexus; (3) along pulmonary artery to ant. coronary plexus, around right coronary art.

Deep cardiac plexus lies behind arch of aorta, upon bifurcation of trachea. *Right half* is formed by superior, middle, inferior cardiac branches of sympathetic in neck, sup. and inf. cardiac branches of vagus in neck, cardiac branches of recurrent n., and of vagus in thorax. *Left half* is formed by middle and inferior cardiac branches of sympathetic, sup. cardiac branch of vagus in neck, cardiac branches of recurrent n., and a contribution from superficial plexus. **Branches** to both anterior pulmonary and both coronary plexuses.

Anterior coronary plexus, formed by branches from superficial and from right half of deep plexus; accompanies right coronary

art.; supplies right atrium and ventricle. **Post. coronary plexus**, formed by branches from both halves of deep plexus, accompanies left coronary art., supplies left atrium and ventricle.

Celiac Plexus (Solar or Epigastric Plexus).—A large plexus lying in front of upper part of abdominal aorta and crura of diaphragm, behind stomach, pancreas, and omental bursa (lesser sac of peritoneum), and vena cava. Surrounds celiac artery; sends large plexuses into suprarenal glands. Subsidiary plexuses from it accompany and surround inf. phrenic, suprarenal, renal, celiac, superior mesenteric arteries and their branches, and are joined by branches of vagi. It is continued downwards over aorta as *aortic plexus*, from which a plexus accompanies inferior mesenteric and its branches. Plexus on spermatic or ovarian artery is derived from aortic and renal plexuses. Renal plexus is joined by lowest splanchnic nerve.

Celiac Ganglion (Semilunar).—Largest peripheral ganglion in the body. $\frac{1}{2}$ to 1 inch in diameter. Irregular and lobulated. Lies on crus of diaphragm, medial to suprarenal gland, at side of celiac artery. The right ganglion is overlapped by vena cava, the left by the pancreas. Branches of celiac plexus are derived from it. Greater and lesser splanchnic nerves end in it.

Hypogastric Plexus.—Lies on promontory of sacrum, between common iliac arteries. Formed by a continuation of aortic plexus, and by branches which descend from sympathetic trunks in front of common iliac arteries. It divides into two *pelvic plexuses*. These subdivide into plexuses which accompany iliac and hypogastric (internal iliac) arteries and their branches, receive their names and are distributed with them. White rami communicantes from 3rd and 4th sacral nerves, and branches from sacral ganglia join them.

ORGANA SENSUUM

NASUS (NOSE)

Nasus Externus.—Formed by nasal bones and frontal processes of maxillæ; lateral and alar cartilages. **Basis**: perforated by *nares* (nostrils). **Radix**: at junction with forehead. **Dorsum**: the anterior border. **Apex**: the free point. **Ala** the expanded mobile lower part of lateral surface, limited above by *alar sulcus*. Skin is thin and movable over upper part, thick and adherent below. *Arteries*, from ext. maxillary (facial) and ophthalmic. *Veins* join anterior facial and ophthalmic. *Nerves*, to muscles from facial; to skin, infra-trochlear and external nasal branches of naso-ciliary and infra-orbital. *Lymphatics* end in submaxillary and anterior auricular lymph glands.

Cartilagine Nasæ. **Cartilago septi nasi**: a broad quadrangular sheet: *postero-superior border* attached to lamina perpendicularis of ethmoid; *postero-inferior*, to vomer and maxillæ; *antero-superior*, to nasal bones above, to fibrous tissue below, continuous with lateral cartilage in middle; *antero-inferior*, to medial crus of greater alar cartilage. *Processus sphenoidalis* projects backwards between vomer and ethmoid.

Cartilago Vomero-nasalis. Narrow strips lying on each side of anterior part of postero-inferior border of septal cartilage.

Cartilago Nasi Lateralis. Triangular; *superior border* attached to nasal bone and frontal process of maxilla, *inferior*, to alar cartilage, *anterior* continuous with septal above, separated from it by fissure below.

Cartilago Alaris Major. *Crus laterale*, large, oval, lies above anterior part of nostril. *Crus mediale* turns backwards in lower part of septum.

Cartilagine Alares Minores.—Small nodules above ala. Ala and *septum nasi mobile* (free edge of septum) are devoid of cartilage.

Cavum Nasi (Nasal Fossa).—Osseous boundaries, meatuses, communications and relations (see p. 50); osseous *lateral wall* is supplemented by lateral and alar cartilages; osseous *septum* by septal cartilage and medial crus of alar cartilage.

Vestibulum nasi: dilated part inside nostril, lined with skin, on lower part of which hairs grow; limited above and behind by curved ridge called *limen nasi*.

Remainder of nasal cavity is lined with muco-periosteum and is divided into **regio olfactoria**, the region of superior concha and corresponding part of septum, and **regio respiratoria**. **Atrium meatus nasi**: a depressed area, anterior to middle meatus, limited antero-superiorly by ridge called *agger nasi*. **Bulla ethmoidalis**: an eminence under cover of middle concha; **hiatus semilunaris**: the curved slit below bulla—both in lateral wall of middle meatus.

Membrana Mucosa.—Thick, very vascular, continuous with that of pharynx and sinuses in neighbourhood, adherent to periosteum, forming a *muco-periosteum*. In respiratory region it is covered with ciliated columnar epithelium and contains numerous glands; in olfactory region, yellowish, more delicate, covered with non-ciliated columnar epithelium, contains tubular, branched olfactory glands.

Arteries, spheno-palatine, ethmoidal, anterior palatine. **Veins** form plexuses, especially dense over conchæ (*plexus cavernosi concharum*), and are drained by facial, ethmoidal, spheno-palatine. **Lymphatics** end in gland in front of 2nd cervical vertebra, in sub-maxillary, and glands near greater horn of hyoid bone. **Nerves**: (1) **Special sense**: olfactory. (2) **Ordinary sensation**: *Septum*, naso-palatine and nasal from spheno-palatine ganglion, medial nasal of naso-ciliary. *Lateral wall*, lateral nasal of naso-ciliary, nasal from spheno-palatine gang. and from ant. palatine and ant. sup. alvcolar.

OCULUS

Bulbus Oculi (Eyeball).—Lies in anterior part of orbit, protected by eyelids and conjunctiva. Composed of segments of two spheres: *anterior* corneal segment, with radius of 8 mm.; *posterior* scleral segment, with radius of 12 mm. Union indicated externally by groove called **sulcus scleræ**. Central points of curvatures are **anterior** and **posterior poles**. **Axis optica**: straight line joining poles. **Æquator**: imaginary line encircling eyeball, midway between poles. **Meridiani**: lines drawn from pole to pole, at right angles to equator. **Diameters**: sagittal and transverse, about 24 mm.; vertical, 23.5 mm.

Eyeball consists of three concentric tunics enclosing three refracting media. *Tunica fibrosa oculi* consists of sclera and cornea. *Tunica vasculosa*, of choroid, ciliary body and iris. Third and innermost tunic is the retina.

Refracting media, from before backwards, are aqueous humor, crystalline lens, vitreous body.

Sclera (White of the Eye).—Dense fibrous tissue. Forms posterior $\frac{5}{6}$ of eyeball. Outer surface separated from fascia bulbi (Tenon) by lymph space. Tendons of *recti* are inserted into it, in front of equator ; of *obliqui*, near or behind equator ; medial rectus is attached nearer the cornea than the others. Oblique muscles are attached more posteriorly than recti, and towards lateral side ; tendon of obliquus superior is more slender than that of inferior : superior and inferior, lateral and medial surfaces of eyeball can, therefore, be identified as well as anterior and posterior, and eyeball can be referred to its side. Anterior, visible part of sclera is covered with conjunctiva. Inner surface is loosely attached to chorioid by pigmented connective tissue called **lamina fusca**. Optic nerve pierces sclera 1 mm. below and 3 mm. on nasal side of posterior pole, and sheath of nerve blends with its outer surface. Ciliary nerves and short posterior ciliary arteries pierce it, around entrance of optic nerve. Long posterior ciliary arteries pierce it, one on each side, a little away from optic n. Four venæ vorticosæ emerge through it, a little posterior to equator. Anterior ciliary arteries pierce it behind sulcus scleræ. It overlaps and is directly continuous with substance of cornea at sulcus scleræ. **Sinus venosus scleræ** (Schlemm) is a circular canal in deeper part of junction and communicates by small openings with scleral veins and with anterior chamber. Ciliary arteries and nerves supply sclera.

Cornea forms anterior $\frac{1}{6}$. Transparent. Vertical curvature greater than transverse. Curvature diminishes with age. *Anterior surface* measures 11 mm. vertically, 11.9 mm. transversely. *Posterior surface* is circular, with diameter of 13 mm. Consists from before backwards of (1) stratified epithelium, continuous with conjunctiva ; (2) lamina elastica anterior ; (3) substantia propria, almost its whole thickness, fibrillated, although homogeneous in appearance ; (4) lamina elastica posterior ; (5) endothelium cameræ anterioris, which is reflected on to anterior surface of iris. Posterior elastic lamina divides at periphery into three sets of fibres : anterior pass into sclera ; middle give attachment to ciliary muscle ; posterior radiate into iris as *ligamentum pectinatum iridis*, amongst fibres of which are *spatia anguli iridis* (Fontana), lined by prolongation of the endothelium, and communicating with anterior chamber and sinus venosus (Schlemm). Cornea is devoid of blood vessels. It is nourished by lymph. Ciliary nerves supply it.

Chorioidea.—Lies between sclera and retina. Firmly attached to sclera only where pierced by optic nerve. Extends anteriorly to ora serrata of retina. Consists of (1) *lamina suprachorioidea*, resembling lamina fusca. (2) *Lamina vasculosa*, containing whorls of veins superficially, which drain into venæ vorticosæ ; and arteries, more deeply, derived from short posterior ciliary. (3) *Lamina*

chorio-capillaris contains a meshwork of capillaries. (4) *Lamina basalis*, transparent, in contact with pigment layer of retina. (*Tapetum* is name given to an additional layer found in some animals. It produces the brilliant iridescent appearance seen in chorioid.)

Corpus ciliare connects chorioid with iris. Consists of ciliary processes internally, ciliary muscle externally. **Processus ciliares** resemble chorioid in structure; consist of about 70 folds radially arranged to form a ring; central end of each, free and rounded, lies behind periphery of iris. **Musculus ciliaris** lies deep to anterior part of sclera. Triangular in antero-posterior section. Consists of radial or meridional fibres and circular fibres. *Fibræ meridionales* arise from corneo-scleral junction and lig. pectinatum iridis, radiate backwards and inwards to ciliary processes and chorioid. *Fibræ circulares* form a ring, internal to radial fibres, at periphery of iris; well developed in hyper-metropic eyes, poorly developed in myopia. Nerve supply of ciliary muscle is from oculo-motor, through ciliary branches of ciliary ganglion. It draws chorioid forwards and slackens suspensory ligament of lens, so that lens can become more convex, in accommodating for near vision.

Iris.—Contractile, perforated. Circular curtain, posterior to cornea, anterior to lens. Peripheral margin is continuous with ciliary body; free margin forms circumference of **pupil**, and rests against lens. Consists of non-striped muscle, pigmented connective tissue, vessels and nerves; covered anteriorly by endothelium, posteriorly by 2 layers of columnar pigmented cells, continuous with stratum pigmenti and pars ciliaris of retina. In blue eyes, pigment is limited to these layers; in dark eyes it is scattered through iris. **Arteries** are from long and anterior ciliary. **Muscles**: *Sphincter pupillæ*, arranged round pupil; diminishes pupil by contraction; supplied by oculo-motor, through short ciliary nerves. *Dilatator pupillæ* radiates from sphincter to periphery of iris; enlarges pupil by contraction; supplied by sympathetic, through short ciliary nerves.

Retina.—**Stratum pigmenti** externally, attached to chorioid, and continued onwards, over ciliary body, to iris. **Nervous stratum**, or retina proper, internally, in contact with vitreous. Consists of (1) *pars optica retinae*, which contains nervous elements and ends behind ciliary body in wavy border, called *ora serrata*; (2) *pars ciliaris retinae*, a thin layer of columnar cells continued from ora serrata, over ciliary body, to iris.

Macula lutea is a small yellowish spot, on retina, at posterior pole of eyeball; its central part is depressed and called *fovea centralis*. The whitish **porus opticus** (optic disc), where optic nerve enters and spreads out into retina, is 1 mm. below and 3 mm. to nasal side of posterior pole; its circumference is raised up—*papilla n. optici*—and its centre is depressed—*excavatio papillæ n. op.* (optic cup). The porus is the "blind spot" of the eye.

Blood Vessels.—**Arteria centralis retinae** and its vein pierce

optic nerve $\frac{7}{8}$ in. behind eyeball; appear at centre of optic disc, divide into *upper* and *lower branches*, which each give off (1) *medial* and *nasal* branches, directed medially; (2) *temporal* and *macular* branches, directed laterally. Macula lutea is supplied by both macular and temporal; fovea centralis has no blood vessels.

Corpus Vitreum occupies posterior $\frac{4}{5}$ of eyeball. Transparent and jelly-like. Consists of **membrana hyaloidea** enclosing loose fibrous **stroma vitreum** and fluid **humor vitreus**, traversed antero-posteriorly by *canalis hyaloideus*. Lens lies in concavity, on anterior surface, called *fossa hyaloidea*. Hyaloid membrane is adherent to retina at optic entrance. Its anterior part is thickened and thrown into radial folds called *zonula ciliaris* (Zinn). Ciliary processes lie in and adhere to furrows between the folds, but folds or ridges are not adherent. The zonula divides near equator of lens into a posterior layer, which forms floor of hyaloid fossa, and an anterior, stronger layer, which is attached to lens, in front of its equator, and forms its **suspensory ligament**. Behind suspensory lig. a sacculated lymph space, called **spatia zonularia** (canal of Petit), encircles equator of lens.

Lens Crystallina.—Transparent, biconvex, circular. 4 mm. in thickness, 9 to 10 mm. in width. Lies on anterior surface of vitreous, posterior to iris and pupil. *Posterior surface* more convex than *anterior*. Central points of surfaces are called *anterior* and *posterior poles*, and line uniting them, the *axis lentis*. Circumference is called the *equator*. Consists of concentric laminae of elongated cells or fibres, enclosed in elastic **capsula lentis**. **Substantia corticalis**, near surfaces, is friable; **nucleus lentis**, at centre, is dense and hard. When the eye is at rest the lens is more flattened owing to tension of suspensory lig., which is attached to capsule. When the eye looks at near object, the ciliary muscle pulls forwards choroid and ciliary processes and adherent zonula, and thus slackens suspensory ligament, and elastic lens becomes more convex owing to removal of tension on its capsule.

Camera oculi anterior (ant. chamber) is the space bounded anteriorly by cornea, posteriorly by iris and central part of anterior surface of lens. **Angulus iridis** is the circumferential angle between cornea and iris.

Camera oculi posterior (post. chamber) is bounded anteriorly by iris, posteriorly by peripheral part of suspensory lig. and adjoining part of lens, circumferentially by free ends of ciliary processes. The chambers communicate through the pupil, and both of them are filled with fluid, called **aqueous humor**.

PALPEBRÆ EYELIDS

United at lateral and medial angles of eye by **lateral** and **medial palpebral commissures**; separated by **rima palpebrarum**, which

is elliptical when open, exposing cornea, except upper and lower margins; transverse when closed, and a little below pupil. Free margins are flat and surmounted by eyelashes in nearly whole extent. Near medial end is the small **papilla lacrimalis**, on which there is an aperture—*punctum lacrimale*. Medial to papillæ eyelashes are absent, and the eyelids bound a triangular space called **lacus lacrimalis**, in which is placed *caruncula lacrimalis*, a reddish body consisting of modified skin and skin glands. In each eyelid, near free margin, there is a condensed fibrous plate, named **tarsus**.

Lig. palpebrale mediale is attached to frontal process of maxilla, in front of lacrimal sac; laterally it divides to be attached to the tarsi. **Raphe palpebralis lateralis** is attached laterally to zygomatic, medially to tarsi. *Superior palpebral ligament* is attached to upper margin of orbit, and blends with tendon of levator palpebræ below. It is pierced by supra-trochlear and supra-orbital nerves and accompanying vessels and by dorsal nasal art. and terminal branches of lacrimal nerve. *Inf. palpebral lig.* extends from lower margin of orbit to inferior tarsus. Sup. and inf. palpebral ligaments form the **palpebral fascia**, which fuses laterally with raphe, but is separated from medial lig. by lacrimal sac.

Glandulæ tarsales (Meibomian) are long sebaceous glands imbedded in tarsi, posteriorly. They open on margin, behind eyelashes. *Ciliary glands of Moll* are modified sweat glands, behind eyelashes. Blocking of duct of one of these gives rise to a "stye."

Conjunctiva is the mucous membrane which covers posterior surfaces of eyelids and is reflected on to anterior surface of sclera. The lines of reflection are called *superior* and *inferior fornix conjunctivæ*. *Plica semilunaris conjunctivæ* is a vertical fold placed lateral to caruncle.

Skin of eyelid is thin and without hairs. **Superficial fascia** is devoid of fat and contains fibres of *orbicularis oculi*.

Upper eyelid is larger and more movable, and has special muscle, **levator palpebræ superioris**, tendon of which splits into three lamellæ:—*anterior* is joined by sup. palpebral lig., is attached to ant. surface of sup. tarsus, and sends fibres, through orbicularis, to skin; *middle* is attached to sup. tarsus; *posterior* is attached to sup. fornix.

Arteries to eyelids, from ophthalmic, superficial temporal, transverse facial. **Veins** end in ophthalmic, superficial temporal, angular. **Lymphatics** end in anterior auricular, parotid and submaxillary lymph glands. **Nerves**: *Sensory*, from supra-orbital, supra-trochlear, infra-orbital, infra-trochlear, lacrimal. *Motor* to orbicularis from facial, to levator from oculo-motor.

APPARATUS LACRIMALIS

Glandula lacrimalis superior lies in fossa lacrimalis on orbital aspect of zygomatic process of frontal, separated from eyeball by

levator palpebræ and rectus lateralis. *Glandula lacrimalis inferior* projects from it into upper eyelid and lies upon conjunctiva. *Ductuli excretorii* open into lateral part of superior fornix of conjunctival sac. *Blood vessels*: lacrimal branches of ophthalmic. *Nerves*: lacrimal and sympathetic.

Ductus lacrimales, superior and inferior, collect the tears and carry them to lacrimal sac. They begin in **puncta lacrimalia** on lacrimal papillæ; run medially in margins of eyelids bounding lacus lacrimalis; join together to open into lacrimal sac, below its middle. **Saccus lacrimalis** lies in lacrimal groove of lacrimal bone and frontal process of maxilla, behind medial palpebral ligament. Upper end is blind; lower end narrows slightly to form **ductus naso-lacrimalis**, which descends for about $\frac{1}{2}$ inch, through osseous naso-lacrimal canal, to open into inferior meatus of nose, near its anterior end, 30 to 35 mm. from posterior margin of nostril. A fold of mucous membrane, called *plica lacrimalis*, projects from medial side of inferior orifice and acts as a valve. Only a small proportion of the tears is led away by the lacrimal ducts. The greater quantity evaporates from the surface of the eye.

ORGANON AUDITUS (ORGAN OF HEARING)

EXTERNAL EAR

Auricle. — Lateral Surface. — Large depression about its middle is the *concha*, leading into ext. acoustic meatus. *Helix*, folded rim, begins as *crus heliis* in concha, dividing it into *cymba conchæ* above, *carum conchæ* below; helix ends in dependent *lobulus*; *tuberculum auriculæ* (Darwin), morphological apex of ear, seen or felt on helix, below and behind top of ear. *Antihelix*, elevation anterior to helix; it divides superiorly into *crura antiheliciis*, which enclose *fossa triangularis*. *Scapha*, depression between helix and antihelix. *Tragus* overlaps anterior part of concha and is separated from crus heliis by *incisura anterior*. *Antitragus* projects over concha from behind and below, and is separated from tragus by *incisura intertragica*. **Medial or cranial surface** bears corresponding elevations and depressions, *eminentia conchæ*, *fossa antihelici*, etc.

Cartilago auriculæ supports auricle, all except lobule, which is composed of fat and fibrous tissue; is continuous with cartilage of meatus; connected to zygoma and mastoid process by *ant.* and *post.* ligaments; anterior, posterior and superior (extrinsic) auricular muscles are inserted into it; various intrinsic muscles and ligaments pass from one point of it to another.

Arteries to auricle, from superficial temporal and post. auricular. **Veins** end in superficial temporal, post. auricular, mastoid emissary vein. **Lymphatics** end in post. and ant. auricular glands, and in

glands accompanying ext. jugular vein. **Nerves:** *motor*, facial; *sensory*, auriculo-temporal, great auricular, lesser occipital, and, sometimes, greater occipital.

External acoustic meatus leads from concha to tympanic membrane; 24 mm. in length from bottom of concha (35 mm. from tragus); owing to obliquity of tympanic membrane its anterior and inferior walls are longer than posterior and superior. Forms an irregular sinuous bend: lateral part (7 mm.) is directed medially, anteriorly and slightly upwards; middle part (5 mm.) medially and posteriorly; medial part (12 mm.), medially, anteriorly and slightly downwards. Widest at lateral end, narrows towards osseous meatus, widens there, but narrows again as it passes medially; *isthmus* or narrowest part is 19 mm. from bottom of concha.

Osseous part (16 mm.) is formed by temporal bone. Lateral part (8 mm.) formed by **cartilage** folded to form groove which is completed above and posteriorly by fibrous tissue; continuous with cartilage of auricle; attached to margin of osseous part by fibrous tissue. In new-born child there is no osseous part, as tympanic plate is only an incomplete ring; and external meatus is very small and short.

Skin is firmly adherent to meatus, and extends on to tympanic membrane. Its *glandule ceruminosae* are modified sweat glands and secrete cerumen or ear wax.

Arteries, from superficial temporal, posterior and deep auricular. **Veins** end in ext. jugular, int. maxillary and pterygoid plexus. **Lymphatics** end like those of auricle. **Nerves**, auriculo-temporal, auricular branch of vagus.

CAVUM TYMPANI OR MIDDLE EAR

Tympanic Cavity.—Lies in temporal bone between tympanic membrane and labyrinth. Communicates with tympanic antrum posteriorly, with nasal pharynx, through auditory (Eustachian) tube, anteriorly. Vertical and antero-posterior diameters are 15 mm. From side to side it measures 6 mm. above, 4 mm. below, $1\frac{1}{2}$ to 2 mm. at middle. Lined with mucous membrane. Contains tympanic ossicles with their ligaments and muscles; chorda tympani nerve; tympanic plexus. **Recessus epitympanicus**, part above level of tympanic membrane, contains greater part of incus and upper $\frac{1}{2}$ of malleus.

Paries tegmentalis (Roof).—Formed by tegmen tympani, which separates it from middle cranial fossa.

Paries jugularis (Floor).—Thin plate separating it from jugular fossa. Internal opening for tympanic branch of glosso-pharyngeal is at junction of floor and medial wall.

Paries mastoidea (Posterior wall) presents, from above down-

wards, (1) *aditus ad antrum*, opening leading from epitympanic recess into tympanic antrum; (2) *fossa incudis*, depression lodging short crus of incus; (3) *eminentia pyramidalis*, at junction of posterior and medial walls, perforated at apex by tendon of stapedius; (4) *apertura tympanica canaliculi chordæ*, near posterior edge of tympanic membrane, close to top, for entrance of chorda tympani into cavity; (5) *prominentia styloidea*, often absent, produced by upward and forward prolongation of styloid process.

Paries carotica, sloping posterior wall of carotid canal, partly in floor and partly in anterior wall; perforated by carotico-tympanic nerves from carotid to tympanic plexus, and by tympanic branch of carotid artery. Above it there is **musculo-tubal canal**, divided by *septum* (processus cochleariformis) into *semicanalis m. tensoris tympani* above, and *semicanalis tube auditivæ* below.

Paries labyrinthica (Medial wall). Formed by lateral surface of osseous labyrinth. Presents—(1) Rounded *promontorium*, produced by first coil of cochlea, grooved by tympanic plexus; (2) *fenestra vestibuli* (ovalis), at bottom of *fossa fenestræ vestib.*, above and posterior to promontory, leads into vestibule, is closed by foot-piece of stapes; (3) *prominentia canalis facialis*, produced by canal of facial nerve as it runs posteriorly, at junction of roof and medial wall, to descend behind posterior wall and end at stylo-mastoid foramen; (4) end of septum of musculo-tubal canal projects backwards over fenestra vestibuli and turns laterally, forming pulley for tendon of tensor tympani; (5) *sinus tympani*, depression behind promontory, opposite ampulla of post. semicircular canal; (6) *fenestra cochleæ* (rotunda), at bottom of *fossa fen. coch.*, below and posterior to promontory, communicates with scala tympani of cochlea, is closed by membrane called *membrana tympani secundaria*.

Paries membranacea (Lateral wall). Small part above is formed by squamous temporal; by far the greater part is formed by *membrana tympani*, which separates cavity from meatus, and is fixed circumferentially to a groove called *ulcus tympanicum*. Bony ring containing this groove is deficient and notched superiorly (notch of Rivinus). In front of upper part of membrane is *petro-tympanic fissure* (Glaserian), at medial end of which is the canal by which chorda tympani leaves tympanum.

Membrana Tympani.—Placed obliquely, so that it forms angle of 55° with anterior and inferior walls of meatus. Circumference is thickened, except opposite notch of Rivinus, and is called *annulus fibro-cartilagineus*; from the ends of the notch it is continued to lateral process of malleus as *plicæ malleolares, anterior* and *posterior*; small and lax triangular portion of membrane between plicæ and opposite notch is called *pars flaccida* (Shrapnell). Remainder of membrane, tightly stretched, is called *pars tensa*. Handle of malleus is attached to membrane and draws it medially so that lateral surface is concave, medial convex. Maximum convexity is the *umbo*,

although the name is usually given to maximum concavity on lateral surface.

Tympanic membrane consists of fibrous tissue (absent from pars flaccida), lined laterally with skin, medially with mucous membrane. *Arteries*: deep auricular and tympanic of int. maxillary, stylo-mastoid of post. auricular. *Veins*: into ext. jugular, transverse sinus, veins of dura, plexus on auditory tube. *Nerves*: auriculo-temporal and auricular branch of vagus to skin surface; tympanic of glosso-pharyngeal to mucous surface.

Tunica mucosa tympanica lines tympanic cavity; is continuous with pharynx, through auditory tube; extends back to line antrum and mastoid air cells; envelops ossicles, muscles and nerves, and, in so doing, is cast into folds which bound little pouches, of which three are related to neck of malleus; *recessus membranae tympani anterior*, in front of it; *r. memb. tymp. posterior*, behind it; *r. m. t. superior*, the largest, between it and pars flaccida, may retain pus, as its opening is near top.

Arteries of tympanic cavity: tympanic of int. maxillary and of int. carotid, stylo-mastoid, petrosal of mid. meningeal; asc. pharyngeal sends branch with tympanic nerve. **Veins** end in pterygoid plexus, mid. meningeal, sup. petrosal sinus. **Nerves**: from tympanic plexus.

ANTRUM TYMPANICUM AND TUBA AUDITIVA

Tympanic Antrum (Mastoid Antrum). — Almost as large at birth as in adult. Diameters about 9 mm. **Situated** $\frac{1}{2}$ to $\frac{3}{4}$ inch internal to suprameatal triangle. *Bounded superiorly* by tegmen tympani, *medially* and *posteriorly* by petrous, *laterally* by junction of squamous and mastoid, *inferiorly* by mastoid temporal. Anteriorly it communicates with epitympanic recess of tympanic cavity by the wide **aditus**, smooth medial wall of which overlies ampullae of sup. and lateral semicircular canals, above and behind canal of facial nerve. As mastoid process grows, **mastoid air cells** develop as diverticula of antrum. They are not limited to mastoid, but extend into adjoining bone.

Auditory Tube (Eustachian). — Trumpet-shaped, $1\frac{1}{2}$ inches long. Leads from anterior wall of tympanic cavity (*ostium tympanicum*) medially, anteriorly, and downwards, to open on lateral wall of nasal pharynx near its centre (*ostium pharyngeum*), about middle of post. border of medial pterygoid lamina, on a level with, and $\frac{1}{2}$ inch behind, posterior end of inferior concha.

Pars ossea, $\frac{1}{2}$ inch long; in substance of temporal bone between tympanic plate and petrous temporal, below canal for tensor tympani, lateral to carotid canal and artery, postero-medial to upper part of mandibular joint. Medial end is found behind and medial to angular spine of sphenoid.

Pars cartilaginea, 1 inch long; fixed to groove between great wing of sphenoid and petrous temporal, on inferior surface of skull; tensor veli palatini arises from its antero-lateral aspect and separates it from mid. meningeal art., mandibular nerve (inf. max. division of V.), and pterygoideus internus. Postero-medial aspect is in relation to mucous membrane of recessus pharyngeus (lateral recess) and levator veli palatini, which partly arises from it, and is at first medial to it and then below. Upper border of superior constrictor is below.

Cartilage is a triangular plate, curled to form superior and medial walls, while infero-lateral wall is formed by fibrous tissue. Apex of plate is fixed to medial end of pars ossea; curved base is free, bounds ostium pharyngeum above and posteriorly, forming prominent torus tubarius (Eustachian cushion), and gives origin to salpingo-pharyngeus muscle, which descends in salpingo-pharyngeal fold, on side wall of pharynx. During deglutition the tube is opened by the muscles attached to it.

Arteries: from ascending pharyngeal and asc. palatine; mid. meningeal, pterygoid (Vidian) of int. maxillary. **Veins** end in pterygoid plexus. **Nerves**: from tympanic plexus and pharyngeal branches of sphenopalatine ganglion.

Development.—From 1st visceral cleft and pouch. Ext. meatus from ectoderm, auditory tube and tympanic cavity from entoderm.

OSSICULA AUDITUS (TYMPANIC OSSICLES)

Malleus.—Largest; 8 to 9 mm. long. Rounded **capitulum**, supported by constricted **collum**, lies in epitympanic recess and is attached to roof by ligament; articulates, by diarthrodial joint, with incus medially. **Processus anterior** projects forwards from neck and is connected by ligament to petro-tympanic (Glaserian) fissure. **Chorda tympani**, as it passes forwards through tympanic cavity, crosses medial side of neck. **Manubrium** projects downwards, medially and backwards, and is attached to tympanic membrane; tensor tympani is inserted into medial side of its upper end. **Processus lateralis** projects laterally from upper end of handle, and plicae malleolares are attached to it.

Incus.—Shaped like a pre-molar tooth, with widely diverging roots. **Corpus** lies in epitympanic recess, articulates laterally with malleus. **Crus breve** projects posteriorly into fossa incudis and is attached there by ligament. **Crus longum** projects downwards; lower end turns medially and ends in a knob, called *processus lenticularis*, which articulates with head of stapes, by a diarthrodial joint.

Stapes.—Stirrup-shaped. **Capitulum** articulates with incus. Stapedius is inserted into post. aspect of *neck*. Diverging **crura**, **anterior** and **posterior**, pass medially and join ends of oval **basis**, or foot-piece, which fits into fenestra vestibuli (ovalis), and is held there by circumferential *lig. annulare baseos stapedis*.

Musculi Ossiculorum Auditus.—**Tensor tympani** arises from cartilage of auditory tube and adjoining great wing of sphenoid; passes through canal above bony auditory tube; enters upper, anterior part of tympanic cavity; turns laterally round pulley-shaped end of septum of musculo-tubal canal, to be *inserted* into upper end of handle of malleus. Draws malleus and tympanic membrane medially, and makes the membrane more tense. *Nerve*, from motor root of mandibular division of trigeminal, through otic ganglion.

Stapedius arises from hollow interior of eminentia pyramidalis. Tendon emerges from apex of eminentia and is *inserted* into post. surface of neck of stapes. Tilts anterior end of foot-piece laterally and posterior end medially. *Nerve*, from facial.

AURIS INTERNA

Internal ear consists of a series of cavities in petrous temporal, called osseous labyrinth, in which is lodged a system of canals and sacs, called membranous labyrinth.

Labyrinthus osseus consists of vestibule, semicircular canals and cochlea.

Vestibulum.—6 mm. antero-posteriorly, 4-5 mm. vertically, 3 mm. from side to side. Communicates anteriorly with cochlea, posteriorly with semicircular canals. Lateral wall corresponds to part of medial wall of tympanum, and fenestra vestibuli (ovalis) is seen in it. Below is the jugular fossa. Facial nerve crosses it above. Medial wall corresponds to bottom of internal meatus and presents antero-inferiorly a depression, called *recessus sphaericus*, which lodges sacculæ and is perforated (*macula cribrosa media*) by 12-15 filaments from cochlear nerve to sacculæ. Ridge bounding r. sphaericus above and posteriorly is called *crista vestibuli*; its antero-superior end is called *pyramis vestibuli*; its postero-inferior end divides to enclose *recessus cochlearis*, perforated by nerves to ductus cochlearis. On roof and medial wall of vestibule, behind crista, is the oval *recessus ellipticus*. Foramina on pyramid and adjacent r. ellipticus (*macula cribrosa superior*) transmit 25-30 filaments from vestibular nerve to utricle and ampullæ of sup. and ext. semicirc. ducts. Behind and below r. ellipticus is the opening of *aquæductus vestibuli*, which passes through petrous for 8-10 mm., opens on its posterior surface, and transmits ductus endo-lymphaticus and small vessels. Vestibule opens anteriorly into scala vestibuli by elliptical opening, bounded inferiorly by beginning of lamina spiralis ossea, on lateral side of r. sphaericus. Interval between lam. spiralis ossea and lateral wall of cochlea (promontory) is narrowed down to form *fissura vestibuli* by a ledge called *lamina spiralis secundaria*, which projects from lateral wall of cochlea.

Canales Semicirculares Ossei, Posterior, Superior, Lateralis.—Behind and above vestibule. Each forms $\frac{2}{3}$ of circle and

is ampullated at one end. **Superior** is vertical, lies across long axis of petrous, and produces arcuate eminence on anterior surface. Ampulla opens into upper part of vestibule. Posterior end joins non-ampullated end of posterior canal to form *crus commune*, which opens into medial part of vestibule. **Posterior** is vertical, parallel to posterior surface of petrous. Upper end joins *crus commune*; lower ampullated end enters lower and posterior part of vestibule, where some apertures (*macula cribrosa inferior*) transmit filaments from cochlear nerve to duct within canal. **Lateral** arches horizontally in lateral direction. Ampullated lateral end opens close below ampulla of superior; other end opens above ampulla of posterior. Lateral canal of one ear is nearly in same plane as that of the other, posterior of one ear is nearly parallel to superior of the other.

Cochlea.—Short cone, lying on its side; base at bottom of internal meatus; apex, directed laterally and anteriorly, lies close to canal for tensor tympani. 9 mm. across base; 5 mm. from base to apex. Consists of tube 28-30 mm. long, coiled spirally $2\frac{1}{2}$ or $2\frac{3}{4}$ times round a central pillar called **modiolus**, which falls short of apex by 1 mm. Coils are called *basal*, *central*, and *apical*. Basal produces promontory on medial wall of tympanum. *Lamina spiralis ossea*, a thin flat shelf, winds round modiolus like the thread of a screw, projecting half-way into cochlear tube, dividing it into **scala vestibuli** on its apical side, **scala tympani** on basal side. It begins at floor of vestibule and ends near apex in a process, called *hamulus*, which assists to bound an aperture called *helicotrema*. From outer wall of lower half of basal coil the *lamina spiralis secundaria* projects inwards, and slit between it and lam. spir. ossea is called *passus vestibuli*. A membrane, called *lamina basilaris*, stretches from free edge of lam. spiralis ossea to outer wall of tube, completing septum between *scalae*, but they communicate with one another through *helicotrema*. Scala tympani begins at fenestra cochleæ (rotunda), which is closed by *membrana tympani secundaria*. Near fenestra is opening of *aqueductus cochleæ*, which runs through petrous for 10-12 mm., and opens at anterior margin of jugular foramen. Through it, s. tympani communicates with subarachnoid space, and it transmits a vein. Scala vestibuli begins in vestibule. Modiolus is channelled by a large number of *canales longitudinales modioli* for cochlear nerves and vessels. They run for varying distances longitudinally and then turn towards attached edge of lamina spiralis ossea, where they dilate and join one another to form *canalis spiralis modioli*, for spiral ganglion. From this spiral canal numerous small canals conduct nerves and vessels to free edge of lamina spiralis to enter spiral organ of Corti.

Labyrinth Membranaceus.—Lies in bony labyrinth but does not nearly fill it. Contains fluid called endolymph, while perilymph occupies space between it and walls of bony labyrinth.

Utriculus.—Small sac, lying in postero-superior part of vestibule, receives the ends of ductus semicirculares. Its highest part, called

recessus utriculi, which lies in *recessus ellipticus*, is thickened in its floor and anterior wall (*macula acustica utriculi*) and receives there the utricular fibres of vestibular nerve.

Sacculus.—Smaller than utricle, lies in *recessus sphaericus* in antero-inferior part of vestibule. A thickening, called *macula acustica sacculi*, receives saccular fibres of cochlear nerve. *Ductus reuniens*, a short canal from lower part of sacculi, opens into cochlear duct near its vestibular end. *Ductus endolymphaticus* leaves posterior part of sacculi; is joined by short *ductus utriculo-saccularis* from utricle; traverses aqua-ductus vestibuli; ends under dura mater, on posterior surface of petrous, as a dilatation called *sacculus endolymphaticus*.

Ductus semicirculares, within bony semicircular canals, attached to their convex sides; are each ampullated at one end; and they open into utricle by five openings.

Ductus Cochlearis (*Scala Media*).—Spiral canal inside bony cochlea on apical side of scala tympani. Both ends are blind: *cæcum vestibulare* lies in vestibule on *recessus cochlearis*; *cæcum cupulare* is fixed to apex of cochlea and helps to bound helicotrema. *Outer wall* is formed by a thickening of periosteum of outer wall of cochlea, called *lig. spirale cochleæ*. *Membrana vestibularis* (Reissner) stretching from periosteum on apical side of lamina spiralis to outer wall of cochlea, forms its *apical wall* and separates its cavity from scala vestibuli. *Basal wall*, separating its cavity from scala tympani, is formed by limbus laminae spiralis and lamina basilaris. *Limbus laminae spiralis* is a thickening of periosteum at, and near, edge of lamina spiralis ossæ. Its outer border is grooved. *Lamina basilaris* extends from basal or tympanic lip of groove to outer wall of cochlea. From its vestibular lip the *membrana tectoria* projects outwards over organ of Corti.

Organon spirale Cortii, the essential end organ of hearing, is placed in ductus cochlearis, on apical side of lamina basilaris.

Artery: internal auditory from basilar. **Veins** join inf. petrosal sinus. **Nerves**: *vestibular* to utricle, superior and external semicircular ducts. *Cochlear* to sacculi, post. semicircular duct, and ductus cochlearis, including spiral organ of Corti.

Internal Acoustic Meatus.—8 mm. long, 3-5 mm. wide. Situated in petrous temporal, medial to internal ear. Opens by an oblique aperture, on post. surface of petrous temporal, into post. cranial fossa. Its *fundus* is formed by a plate of bone, called **lamina cribrosa**, which separates it from vestibule and cochlea, and is perforated by facial nerve, the branches of vestibular and cochlear divisions of acoustic nerve, and the int. auditory vessels.

RESPIRATORY APPARATUS

AIR drawn into the two lungs by movements of inspiration passes successively through the cavities of **nose**, **pharynx**, **larynx**, **trachea** or windpipe, and the two **bronchi**, into which trachea divides. Nasal cavities are situated in the head, pharynx in head and neck, larynx in neck, trachea in neck and thorax, bronchi in thorax, lungs in thorax and root of neck. The lungs are covered by membrane called **pleura**.

Nose and Nasal Cavities. — See Organs of the Senses, p. 403. **Pharynx.** — See Digestive Apparatus, p. 446.

LARYNX

The organ of voice, situated below hyoid bone and tongue, between carotid sheaths, and, reckoning tip of epiglottis as upper end, in front of 3rd, 4th, 5th, 6th cervical vertebræ, separated from them by pharynx and pre-vertebral muscles. In relation antero-laterally with thyroid gland and depressors of hyoid, and overlapped by sterno-mastoid. In foetus it is opposite 3rd and 4th C. vertebræ. Gradually descends till puberty. Position varies with movements of head, and during deglutition and vocalisation.

CARTILAGES OF LARYNX

Unpaired : thyroid, cricoid, epiglottic. **Paired :** arytaenoid, corniculate, cuneiform.

Thyroid Cartilage. — Two quadrilateral laminæ. *Anterior borders* fused below, separated by **incisura thyroidea** above.

Very prominent above, in adult male, forming **prominentia laryngea** (Adam's apple). *Posterior border*, free and rounded, projects upwards and downwards as **sup.** and **inf. cornua**. Sup. horn is connected with greater horn of hyoid by lateral thyreo-hyoid lig., in which is developed a small nodule of cartilage—*cartilago triticea*. Inf. horn articulates with side of cricoid. *Superior border* convex; *inferior border* nearly horizontal. **Linea obliqua** begins at *sup. tubercle* on lateral surface, below sup. border, in front of sup. horn; extends downwards and forwards to end at *inf. tubercle*, behind middle of inf. border. Medial surface is smooth and slightly concave.

Extrinsic muscles attached are inf. constrictor to oblique line and surface behind it; stylo-pharyngeus and pharyngo-palatinus to post. border; sterno-thyroid and thyreo-hyoid to oblique line.

Cricoid Cartilage.—Situated below thyreoid cartilage; shaped like a signet-ring; consists of broad *lamina* posteriorly, and narrow *arch* anteriorly. **Lamina**: post. surface shows two hollows for post. crico-arytænoid muscles, separated by median ridge. Sup. border is notched in median plane, and has facet for arytænoid cartilage on each side. **Arch**: narrow anteriorly, broadens to join lamina posteriorly; facet for inf. horn of thyreoid on junction, near lower border. Sup. border slopes upwards and backwards. Inf. border is in horizontal plane with that of lamina.

Extrinsic muscles.—Inf. constrictor to the side. Some fibres of oesophagus to median ridge.

Epiglottic Cartilage.—Situated posterior to thyreo-hyoid membrane, hyoid bone and root of tongue; anterior to sup. aperture of larynx. Shaped like a leaf; *superior end* free; *inf. end* or stalk is attached by **thyreo-epiglottic lig.** to receding angle between laminae of thyreoid. *Margins* are enclosed in ary-epiglottic folds of mucous membrane. *Post. surface* is covered with mucous membrane; lower part is bulged backwards to form *tuberculum epiglotticum*. *Ant. surface*: upper part is free and covered with mucous membrane; lower part is separated by pad of fat from median thyreo-hyoid ligament, and connected with hyoid by **hyo-epiglottic ligament**.

Glosso-epiglottic fold is a fold of mucous membrane raised up in median plane between epiglottis and base of tongue.

Pharyngo-epiglottic folds of mucous membrane extend from sides of epiglottis to pharynx, at side of base of tongue. **Vallecula epiglottica** is a depression, on each side, between the folds.

Arytænoid Cartilages.—Situated on superior border of lamina of cricoid. Each is a 3-sided pyramid. *Surfaces*: medial, antero-lateral and posterior. *Apex*, above, supports corniculate cartilage. *Base* articulates with lamina of cricoid. Ant. angle of base is prolonged forwards as **vocal process**; lateral angle is enlarged for insertions of post. and lat. crico-arytænoid, thyreo-arytænoid and vocalis muscles, and is called **muscular process**.

Corniculate cartilages: small nodule on apex of each arytenoid, in ary-epiglottic fold.

Cuneiform cartilages: small rod-shaped piece of cartilage in each ary-epiglottic fold, anterior to apex of arytenoid.

Thyreoid, cricoid, and bases of arytenoids are hyaline and begin to ossify after 20, and are completely ossified at advanced age. Other cartilages are yellow fibro-cartilage.

ARTICULATIONS, LIGAMENTS, AND MEMBRANES OF LARYNX

Crico-thyreoid Joint.—Diarthrodial; inf. horn of thyreoid connected with side of cricoid by *articular capsule*, strengthened posteriorly. **Movements:** rotatory around transverse axis, and gliding movements.

Crico-arytenoid Joint.—Diarthrodial; base of arytenoid connected with upper border of lamina of cricoid by *articular capsule*, thickened posteriorly to arrest forward movement. **Movements:** rotatory around vertical axis, and gliding in all directions.

Membrana Hyothyreoidea (Thyreohyoid Membrane).—Attached superiorly to deep aspect of hyoid bone, inferiorly to sup. horn and upper margin of laminae of thyreoid. Median thickened portion is called **median thyreohyoid lig.**, which is attached to *upper* margin of body of hyoid and to margins of notch of thyreoid; it is related posteriorly to epiglottis, anteriorly it is separated by bursa from hyoid above, and is crossed by hyoid branch of sup. thyreoid art. below. Deep surface of *lateral part* of membrane is related to mucous membrane of pharynx; superficial surface is related to thyreohyoid muscle; it is pierced by internal laryngeal nerve and sup. laryngeal vessels. Its thickened margin, connecting tips of greater horn of hyoid and sup. horn of thyreoid, is called **lateral thyreohyoid lig.**

Crico-thyreoid Lig.—Thick and triangular; attached below, by base, to upper border of arch of cricoid; above, to lower border of thyreoid. Crossed superficially by crico-thyreoid artery.

Conus Elasticus (O.T. lateral part of crico-thyroid memb.).—Thin; attached inferiorly to cricoid, posteriorly to base of arytenoid; anteriorly to deep surface of thyreoid near angle, and is continuous with crico-thyreoid lig. Slopes upwards and medially to end in thickened free border. Covered medially by mucous membrane, laterally by vocalis muscle.

Ligamentum vocale is the free upper border of conus elasticus. Composed of yellow elastic fibres. Supports plica vocalis (vocal cord). Attached anteriorly to thyreoid near receding angle, posteriorly to vocal process of arytenoid.

Ligamentum ventriculare supports plica ventricularis (false

vocal cord); weak and indefinite. Situated above lig. vocale. Extends from thyreoid, near angle, to antero-lateral surface of arytenoid.

Crico-tracheal ligament connects lower border of cricoid with upper end of trachea.

INTERIOR OF LARYNX

Aditus Laryngis (Superior Aperture).—Large and directed obliquely backwards and upwards into laryngeal part of pharynx. *Formed anteriorly* by epiglottis, *posteriorly* by mucous membrane in interval between arytenoids; *at each side* by broad **ary-epiglottic fold** of mucous membrane, which stretches between arytenoid and edge of epiglottis. On each side of aditus is a recess, called **recessus piriformis**, between lamina of thyreoid and ary-epiglottic fold.

Vestibulum laryngis extends from aditus to plicæ ventriculares. Its walls are formed by epiglottis, ary-epiglottic folds, and small fold of mucous membrane in interval between arytenoids.

Plica Ventricularis (False Vocal Cord).—A fold of mucous membrane, supported by lig. ventriculare, extending from angle of thyreoid at attachment of thyreo-epiglottic lig., backwards along each side of cavity of larynx, as far as cuneiform cartilage. **Rima vestibuli** (false glottis) is the interval between plicæ of the two sides.

Plica Vocalis (True Vocal Cord).—A sharp prominent fold of mucous membrane supported by and firmly bound to lig. vocale; extends from angle of thyreoid to vocal process of arytenoid, below and medial to plica ventricularis.

Rima glottidis consists of (1) interval between plicæ vocales—*intermembranous part*; and (2) the interval between bases and vocal processes of arytenoids—*intercartilaginous part*. Narrower than rima vestibuli; therefore all the plicæ can be seen from above, but only plicæ vocales from below.

Rima is opposite junction of upper and middle thirds of anterior border of thyreoid cartilage. Length in male is nearly 1 inch, in female nearly $\frac{3}{4}$ inch. Equal in two sexes up to puberty. Rapidly increases in male after puberty. Intermembranous part is about $\frac{2}{3}$ of whole length.

Ventriculus laryngis is a depression between plica ventricularis and plica vocalis on each side. **Appendix ventriculi** is a diverticulum of mucous membrane, extending from ventricle upwards between plica ventricularis and lamina of thyreoid cartilage.

Tunica mucosa laryngis (mucous membrane), continuous with that of pharynx above and trachea below. Loosely bound down, except over epiglottis and plicæ vocales; on the plicæ, it is also very thin and its cells squamous. **Mucous glands**: scattered all over, especially plentiful over epiglottis, around cuneiform cartilages,

in plica ventricularis, ventricle and appendix; *absent from plica vocalis.*

INTRINSIC MUSCLES OF LARYNX

Crico-thyreoideus.—Lies on exterior of larynx inferiorly. **Arises** from lower border and lateral surface of cricoid. Directed backwards and upwards to be **inserted** into inf. cornu and inf. border of lamina of thyreoid. **Nerve**: ext. laryngeal. It pulls and rotates thyreoid downwards and forwards (or cricoid upwards and backwards), and so renders plicæ vocales tense.

Crico-arytænoideus Posterior.—**Origin**: post. surface of lamina of cricoid. Directed upwards and laterally to be **inserted** into muscular process of arytenoid. **Nerve**: *thin and succeeding muscles by inferior laryngeal.* It rotates arytenoid so that vocal process, with plica, is swung laterally and rima glottidis is widened.

Crico-arytænoideus Lateralis.—**Origin**: upper border of lateral part of arch of cricoid. Directed upwards and backwards to be **inserted** into muscular process of arytenoid. It rotates arytenoid so that vocal process is swung medially and rima glottidis is narrowed.

Musculus Vocalis.—**Origin**: lower part of deep surface of lamina of thyreoid near angle, and from lig. vocale. **Insertion**: muscular process and antero-lateral surface of arytenoid. Draws arytenoid towards thyreoid and so relaxes plica vocalis; may tighten different segments of plica by means of fibres arising from it. **Thyreo-arytænoideus** is merely the superficial part of vocalis.

Arytænoideus Transversus.—The only unpaired muscle in larynx. Passes from posterior surface of one arytenoid to that of the other. Draws posterior parts of arytenoid cartilages together so that rima is narrowed there, but rotates them so that vocal processes are swung laterally and rima is widened between their tips.

Arytænoideus Obliquus.—Superficial to transversus. Extends from muscular process of one arytenoid to apex of other, and then onwards as **ary-epiglotticus**, in ary-epiglottic fold, to side of epiglottis. It draws arytenoids together and narrows rima glottidis; shortens ary-epiglottic fold and approximates arytenoids and epiglottis during deglutition, acting as a sphincter of superior aperture of larynx.

Thyreo-epiglotticus.—Some of upper fibres of thyreo-arytænoideus which curve upwards into ary-epiglottic fold to reach side of epiglottis. It shortens ary-epiglottic fold and pulls tubercle of epiglottis against arytenoids during deglutition.

NERVES AND VESSELS OF LARYNX

Superior laryngeal branch of vagus, by internal branch, supplies mucous membrane; by external branch, supplies

crico-thyreoideus. Recurrent branch of vagus, by its internal laryngeal continuation, supplies other muscles, all on their external aspect.

Vessels.—Sup. laryngeal of sup. thyroid art. Inferior laryngeal of inf. thyroid. Lymphatics from upper part end in upper deep cervical glands at bifurcation of common carotid; from lower part in pre-laryngeal, pre- and para-tracheal, and lower deep cervical glands.

TRACHEA AND BRONCHI

Trachea begins at lower border of cricoid cartilage, opposite lower border of 6th C. vertebra. Ends by dividing into two bronchi opposite upper border of 5th thoracic vertebra and opposite sternal angle. Lies in median plane, except lower end, which is slightly to the right. Upper half is in neck, lower half in sup. mediastinum. Length in male 4-4½ in., female 3½-4 in.

Relations. **In Neck.**—*Anterior*: deep fascia, communication between ant. jugular veins; sterno-hyoid, sterno-thyroid; isthmus of thyroid gland opposite upper 3 or 4 rings; *above isthmus*, the pyramidal lobe, levator glandulæ, and anastomosis between anterior branches of superior thyroid arteries; *below isthmus*, thymus, inf. thyroid veins; occasional thyroidea ima artery; pre-tracheal fascia. *Lateral*: lateral lobe of thyroid, down to 5th or 6th ring; common carotid, and, on right side, innominate art. as well. *Posterior*: œsophagus, and recurrent n. on each side, in groove between trachea and œsophagus; longus colli muscles and vertebral column.

In Thorax.—*Anterior*: manubrium; sterno-thyroids; thymus; left innominate vein; aortic arch, innominate and left common carotid arteries. Lymph glands, and deep cardiac plexus at bifurcation.

Right side: vagus, vena azygos, pleura and lung. *Left side*: aortic arch, left subclavian artery, pleura and lung. Recurrent n. in groove between trachea and œsophagus. *Posterior*: œsophagus, longi colli, vertebral column.

Bronchi extend laterally and downwards from bifurcation of trachea, and each enters hilum of its lung, opposite 6th TH. vertebra. Right bronchus is wider, more vertical, and only about half the length (1 in.) of left. Left bronchus is longer (2 in.) and more horizontal, because (1) end of trachea is slightly to right of median plane, (2) hilum of left lung is

further from median plane than that of right, and (3) heart projects more to left side.

Relations.—**Right bronchus** gives *eparterial bronchus* to upper lobe and divides into branches for middle and lower lobes of lung. Pulmonary art. is below and anterior to main stem, and passes between eparterial branch and remaining *hyparterial* part to reach posterior aspect of branches within lung. Upper pulmonary vein is anterior; lower is below. Post. pulmonary plexus and bronchial vessels are posterior. Vena azygos is behind and above.

Left bronchus divides into branches for upper and lower lobes of lung. Pulmonary art. at first anterior, curves round supero-lateral border to reach postero-lateral aspect. Upper pulmonary vein is anterior; lower is below. Arch of aorta is above. Posterior pulmonary plexus and bronchial vessels, œsophagus, and descending aorta are posterior.

Trachea consists of tube of fibro-elastic membrane kept patent by 15 to 20 cartilaginous rings, which are deficient posteriorly and are replaced by **musculus trachealis**, composed of transverse plain fibres, supplied by recurrent n. **Mucous membrane** contains many mucous glands, much lymphoid tissue, and is lined with columnar ciliated epithelium. Structure of **bronchi** is similar.

Within the lungs the bronchi give off dorsal and ventral branches. Branches of pulmonary veins are anterior to them, branches of pulmonary artery are posterior.

Arteries to trachea, from inferior thyreoid. **Veins** end in thyreoid plexus and inferior thyreoid. **Lymphatics** end in pre- and para-tracheal, lower deep cervical and tracheo-bronchial glands. **Nerves**, from recurrent laryngeal and sympathetic.

Arteries to bronchi: two *left* from descending aorta, one *right* from 1st right aortic intercostal or upper left bronchial or aorta. **Veins**: *right* ends in v. azygos, *left* in v. hemi-azygos accessoria. **Lymphatics** end in bronchial glands. **Nerves**, from vagus and sympathetic, through pulmonary plexuses.

CAVUM THORACIS AND PLEURÆ

Cavity of thorax is subdivided into two pleural cavities, and an intervening region, called **mediastinum**, occupied by structures in or near to median plane, collectively called *mediastinal septum*. Each pleural cavity is enclosed by pleura and contains a lung. Each **pleura** consists of two parts, continuous with one another over root of lung:—i.

Pleura pulmonalis covers and is adherent to lung, and dips into fissures. (ii.) **Pleura parietalis** lines walls of pleural cavity, and is subdivided into four: (1) **Costal pleura** lines ribs and intercostal spaces. (2) **Diaphragmatic pleura** covers great part of diaphragm. (3) **Mediastinal pleura** extends from anterior to posterior wall of thorax, covering mediastinal septum; part which covers side of pericardium is called **pericardial pleura**. It is reflected over root of lung, and becomes continuous with pulmonic pleura around hilum of lung. Pleura clothing lower aspect of root is projected downwards as fold, called **lig. pulmonale** (lig. latum pulmonis), which consists of two closely applied layers, continuous *superiorly* with pleura on ant. and post. aspects of root of lung, *medially* with pericardial pleura, *laterally* with pulmonic pleura below hilum, and *inferiorly* with one another, forming a free lower border. (4) **Cupula pleuræ** (*cervical pleura*) reaches to level of neck of 1st rib posteriorly, but, owing to obliquity of rib, it lies in root of neck anteriorly, extending from $1\frac{1}{2}$ to 2 inches above 1st cartilage, and $\frac{1}{2}$ to 1 inch above sternal third of clavicle. It is covered by Sibson's fascia; supported laterally by scalenus medius, antero-laterally by scalenus anterior. In relation anteriorly with subclavian art., its branches, and structures related to the artery.

Continuity of pleural membrane may be followed by beginning, say, at 3rd left costal cartilage, passing round deep surfaces of ribs to vertebral column; forwards over aorta to root of lung; laterally along root; around lung to front of root of lung; medially along root, and forwards over pericardium to starting-point.

Surface of healthy pleura is smooth and glistening. Pleural cavity is normally only a capillary interval separating pulmonic and parietal pleura. It contains a little fluid, enough to lubricate surfaces. Lower border of lung does not extend so far down as pleura, so that lower part of costal pleura is in contact with diaphragmatic, and capillary interval between them is called **phrenico-costal sinus**. Similarly, anterior margins of lungs may fall short of pleura, and lower part of ant. margin of left lung always does so, and space left is called **costo-mediastinal sinus**.

Lines of pleural reflection are lines along which costal pleura becomes continuous with mediastinal pleura anteriorly and posteriorly, and with diaphragmatic pleura inferiorly.

Posterior line, on right side, corresponds to lateral parts of ventral surface of bodies of vertebræ; on left side, reflection takes place

along sides of bodies, owing to position of œsophagus above and aorta below being to the left of median plane.

Anterior line (excluding apex) is marked on surface, *on right side*, by line drawn from upper part of sterno-clav. joint to centre of manubrium, and then downwards, with slight deviation to left, to sterno-xiphoid junction; *on left side*, by line from sterno-clav. joint to centre of manubrium. From this point to the level of 4th costal cartilage the pleura meet, or right overlaps left. Below that, left pleural line suddenly deviates to the left and then descends along side of sternum to 6th cartilage.

Diaphragmatic line is drawn from end of anterior line, laterally and downwards, to cross 8th rib in mid-clavicular line, then laterally and backwards, convex downwards, to cross 10th rib in mid-axillary line, 2 inches above lower margin of thorax, and to end on level with 12th thoracic spine. Lowest point is in mid-axillary line; **and pleura falls below the level of vertebral end of 12th rib.**

Pleura is held in position along line of diaphragmatic reflection by *phrenico-pleural fascia*, which connects it to uncovered part of diaphragm and to costal cartilages.

Outline of cervical pleura is indicated by a curved line, convex upwards, drawn from sterno-clavicular joint to junction of medial and intermediate thirds of clavicle, its highest point being $\frac{1}{2}$ -1 in. above clavicle.

Blood-vessels: from internal mammary, intercostals, musculo-phrenic, bronchial and pericardial. **Lymphatics**: from visceral pleura to broncho-pulmonary glands, from parietal to intercostal and sternal glands, and from cupola to lower deep cervical or adjacent lymph trunks. **Nerves**: phrenic and intercostal to parietal; sympathetic, through pulmonary plexuses, to visceral.

MEDIASTINUM

Mediastinum is the region between two pleural sacs. Subdivided by pericardium into four: (1) **Middle mediastinum**, occupied by pericardium with its contents, and by phrenic nerves and accompanying vessels. (2) **Superior mediastinum**, above pericardium. *Bounded anteriorly* by manubrium and sterno-thyroids and sterno-hyoids, *posteriorly* by upper 4 TH. vertebrae and longi colli, *at sides* by mediastinal pleura, *inferiorly* by oblique plane drawn between lower borders of manubrium and 4th TH. vertebra. *Contents*: aortic arch and its 3 branches; thoracic parts of innominate veins and extra-pericardial part of sup. v. cava, and arch of vena azygos; trachea, œsophagus; thoracic and right lymphatic ducts; vagi, phrenics, left recurrent n., cardiac nerves; thymus; lymph glands, especially at bifurcation of trachea. (3) **Anterior mediastinum**, in front of pericardium. *Bounded anteriorly* by body of sternum,

posteriorly by pericardium. Above level of 4th cartilage it exists only after dissection. *Contains* areolar tissue, lymph glands and vessels. (4) **Posterior mediastinum**, behind pericardium. *Bounded anteriorly* by pericardium and post. surface of diaphragm, *posteriorly* by lower 8 TH. vertebrae, *at sides* by mediastinal pleura. *Contents* : descending thoracic aorta and its branches, œsophagus, vagi, azygos and hemiazygos veins, thoracic duct, post. mediastinal lymph glands.

Relations in Superior Mediastinum

Thymus.—Two lobes bound together and ensheathed by fascia. Lies *posterior* to manubrium and sterno-hyoids and sterno-thyroids ; overlapped below by pleuræ. Lies *anterior* to left innominate and inf. thyroid veins ; aortic arch, innominate and left common carotid arteries. It extends up into neck, lying upon these two arteries and trachea ; and inferiorly it reaches the pericardium. *Arteries* : from int. mammary and thyroid. *Nerves* : from vagus and sympathetic. *Lymphatics* end in ant. mediastinal, sternal and tracheo-bronchial and lower deep cervical glands.

Right innominate vein begins in neck, where it lies between medial end of clavicle and pleura (p. 214). In thorax, 1st cartilage is *anterior* to it ; phrenic nerve, pleura, lung arc *lateral* ; innominate art. is *medial* ; trachea is postero-medial, some distance away. It lies in a groove on medial surface of pleura and lung, so that they are somewhat posterior and anterior as well as lateral, and overlap its termination at lower border of 1st cartilage. **Tributaries** : vertebral and 1st intercostal vein and right lymphatic duct, in neck ; int. mammary and inf. thyroid veins, in thorax.

Left innominate vein also begins in neck, between clavicle and pleura (p. 217). In thorax it passes to the right and slightly downwards, near upper border of manubrium, *posterior* to thymus, sterno-thyroids, manubrium and 1st right cartilage, to end at its lower border by joining right vein to form sup. cava ; *anterior* to left common carotid and innominate art., and, between them on deeper plane, trachea and pre-tracheal fascia. Aortic arch is *inferior*. **Tributaries** correspond to those of right vein, and, in addition, the left superior intercostal vein ends in it.

Inferior thyroid veins run downwards for a short distance in thorax, anterior to trachea and innominate artery, posterior to thymus, and end in respective innominates, or may join into one trunk which may end in either innominate. **Venæ comites** of int. mammary art. unite to form one trunk, on each side, which ends in innominate vein, at superior aperture of thorax.

Left superior intercostal vein, from 2nd and 3rd spaces, descends slightly to aortic arch, then passes forwards, upwards and to the right, across aortic arch and root of left subclavian artery, to end in

left innominate; pleura and phrenic nerve are on its left, other nerves crossing aortic arch are on its right.

Superior vena cava commences posterior to lower border of 1st right cartilage by the union of two innominates; pierces pericardium opposite 2nd cartilage, ends in upper and posterior part of right atrium opposite 3rd cartilage. **Part in superior mediastinum** lies in a groove on medial surface of lung, so that pleura and lung are posterior, to the right, and anterior, the overlapping anterior margin separating it from int. mammary vessels, structures in 1st intercostal space and edge of manubrium. Phrenic nerve and accompanying vessels are to its right side, between it and pleura. Termination of asc. aorta and origin of innominate art. are to its left. Trachea, vagus and cervical cardiac nerves are posterior and to the left, some distance away. V. azygos enters posterior surface just above pericardium.

(Part of sup. v. cava within fibrous pericardium is covered on anterior, right and left aspects by serous pericardium. Ascending aorta is to its left and anterior; pericardium separates it from pleura and lung anteriorly; from phrenic nerve and pericardiaco-phrenic vessels, pleura and lung laterally; from upper right pulmonary vein, right pulmonary art. and right bronchus, posteriorly.)

As the **vena azygos** arches forwards to join vena cava, it lies in a groove on medial surface of lung above hilum, and lung and pleura are then to its right and above. Root of lung is first anterior, but chiefly inferior. Œsophagus, vagus and trachea are to the left.

Aortic arch lies obliquely across lowest part of sup. mediastinum. Begins behind right margin of sternum, opposite 2nd right cartilage, passes *backwards* and to the left, and ends at lower border of left side of 4th TH. vertebra; curved with a concavity downwards, and curved with a concavity to the right and posteriorly.

Upper convex aspect gives off 3 branches—innominate, left common carotid and left subclavian; and left innominate vein is above it, anterior to these branches.

Anterior part of its **left surface** is separated from lower $\frac{1}{2}$ of manubrium by thymus, and by ant. margins of right and left pleura and lungs, if they meet at centre of manubrium. More posteriorly it lies in groove on medial surface of left pleura and lung, above hilum; and, descending across it, are the left phrenic, inf. cervical cardiac branch of left vagus, sup. cerv. card. branch of left sympathetic, and the left vagus, in that order from before backwards; and the left sup. intercostal vein passes forwards, upwards, and to the right over it.

On right side of arch are lower end of trachea and deep cardiac plexus, œsophagus, recurrent nerve between trachea and œsophagus, and thoracic duct on left border of œsophagus.

Below the arch are: (1) bifurcation of pulmonary art.; (2) root of left lung; (3) lig. arteriosum, in substance of fibrous pericardium, stretching from root of left pulmonary art. to the arch; (4) superficial

cardiac plexus, to the right of and anterior to lig. arteriosum; (5) recurrent branch of vagus, hooking round arch, on left side of, and posterior to, lig. arteriosum.

Innominate artery arises from upper aspect of aortic arch opposite middle of manubrium. Extends upwards and to the right into neck, to end, posterior to upper part of right sterno-clav. joint, by dividing into right common carotid and subclavian. No other branches, except occasional thyroidea ima. In thorax, the manubrium, sterno-hyoid and sterno-thyreoid, and thymus are *anterior to it*; and left innominate vein crosses it, deep to thymus; inf. thyreoid vein or veins descend anterior to it to join right innominate. Trachea and pre-tracheal fascia are *posterior*. Lower part of right innominate vein and beginning of sup. cava are *on its right side*. Left common carotid is *on its left side* and slightly posterior.

(In the neck, trachea is on its left, innominate vein on its right; thymus, sterno-thyreoid, sterno-hyoid, sterno-clavicular joint are anterior. Fat and areolar tissue separate it from longus colli and pleura posteriorly; and vagus is postero-lateral.)

Left common carotid artery arises from upper aspect of aortic arch, close to innominate, on its left side and slightly posterior to it. Extends upwards and to the left, passing from anterior surface of trachea to its left side, and enters neck posterior to left sterno-clav. joint. No branches in thorax. *Anterior to it* are manubrium, sterno-hyoid, sterno-thyreoid, thymus, left innominate vein, origin of innominate art. *On right side* are innominate art. below, trachea above. *Posterior to it*: trachea below, recurrent n. and œsophagus above. Subclavian art. is posterior and to the left. *On its left side*, anterior to subclavian art., are phrenic, vagus and cardiac nerves, pleura and lung.

Left subclavian artery arises from upper aspect of aortic arch, posterior and to the left of carotid, a little distance from it. Ascends in a groove on medial surface of lung, and enters neck posterior to sternal end of clavicle, some distance away from it. No branches in thorax. *Anterior* and to the right are the vagus, phrenic and cardiac nerves and left common carotid. *On its right side* at first is the trachea, and higher up the recurrent n. and œsophagus. *Posterior to it* medially, are œsophagus below, thoracic duct and longus colli above, and posterior to it, laterally, are pleura and lung. Pleura and lung are *on its left side*, and, since it lies in a groove, they are slightly anterior as well; and left superior intercostal vein often crosses its root.

Trachea occupies median plane, but inclines slightly to the right at lower end, and ends by dividing into two bronchi opposite upper border of 5th vertebra and opposite sternal angle.

Anterior to it are: (1) manubrium; (2) sterno-thyreoids, at its upper part; (3) anterior margins of pleuræ, meeting at lower part; (4) thymus, posterior to all these; (5) left innominate vein, crossing obliquely, posterior to thymus; (6) aortic arch, above lower end of trachea; (7) innominate and left common carotid, arising on anterior

aspect of trachea, and diverging as they ascend, posterior to left innominate vein ; (8) pre-tracheal fascia ; (9) lymph glands, and deep cardiac plexus at bifurcation ; (10) superior vena cava and lower end of innominate vein are anterior and to right side, a little distance away, separated by fatty areolar tissue.

On left side are : (1) aortic arch, inferiorly ; (2) subclavian, ascending from arch ; (3) left common carotid, as it enters neck ; (4) vagus and phrenic, descending anterior to subclavian art., separated from trachea by left common carotid and subclavian arteries ; (5) cervical cardiac branches of vagus and sympathetic—those to deep cardiac plexus are first on left side of trachea and then anterior, those to superficial plexus accompany phrenic and vagus ; (6) lateral to all these, the left pleura and lung.

On its right side are : (1) pleura and lung ; (2) vagus passing downwards and backwards to reach back of bronchus ; (3) cervical cardiac branches of sympathetic, and of vagus and recurrent n., descending along the side of trachea, but gaining ant. aspect at lower end ; (4) vena azygos arching forwards, having pleura and lung on its right, vagus and lower end of trachea on its left. *Posterior to trachea* are : (1) œsophagus ; (2) longus colli muscles ; (3) vertebral column ; (4) left recurrent n., in groove between trachea and œsophagus ; (5) v. azygos may be posterior to lower end as it emerges from behind œsophagus.

Œsophagus lies between trachea and longi colli. *On its right side* are pleura and lung, separated only by v. azygos, where it arches forwards at junction of sup. and post. mediastina. *On the left side*, the left recurrent n. is between it and trachea, and thoracic duct, having come from its posterior aspect, runs up along left border. Aortic arch covers left border in lower part of mediastinum. Above the arch the subclavian art. is anterior, and pleura and lung are lateral to left border, higher up, common carotid is anterior and subclavian is lateral.

Right phrenic nerve enters thorax, accompanied by pericardiaco-phrenic art., on lateral side of right innominate vein, and descends through superior mediastinum, with pleura and lung *on its right*, innominate vein and sup. cava *on its left*. [In middle mediastinum it has pleura and lung *on its right*, pericardium and termination of inf. vena cava *on its left*, root of lung and pulmonary lig. (lig. latum pulmonis) *posterior to it*, some distance away.]

Left phrenic nerve, accompanied by pericardiaco-phrenic art., leaves post. aspect of left innominate vein and enters thorax, anterior to subclavian art., on medial surface of pleura ; and pleura and lung are *on its left side* throughout thoracic course. In sup. mediastinum, it lies anterior to subclavian, to the left of common carotid, and crosses vagus, superficially, from behind forwards (or latero-medially) ; lower down, it descends on the left side of left superior intercostal vein and aortic arch, where it is anterior to (or to the right of) vagus and the two superficial cardiac nerves. [In middle mediastinum, pericardium is on its right, pleura on the left ; root of lung and pulmonary lig.

are posterior to it, some distance away. Phrenic nerves give branches to pleura and pericardium, and *supply diaphragm*, after piercing it.]

Right vagus nerve leaves neck by passing downwards and backwards between innominate art. and vein, and enters thorax as it turns medially, on a plane posterior to the art., to reach the side of trachea; descends on side of trachea, with pleura and lung and arch of azygos vein on its right side, and breaks up into post. pulmonary plexus on post. aspect of root of lung. While on trachea it gives branches to œsophagus, and branches which descend to deep cardiac plexus, and branches to ant. pulmonary plexus.

Left vagus nerve leaves post. aspect of left innominate vein; enters thorax; descends between left subclavian and common carotid arteries; is crossed, superficially, from behind forwards (or from left to right), by phrenic nerve; crosses left surface of aortic arch, behind and to the left of phrenic and nerves going to superficial cardiac plexus. On the arch, it is crossed superficially by left sup. intercostal vein. It gives off recurrent branch, and branches to anterior pulmonary plexus, as it leaves arch to break up into post. pulmonary plexus on post. aspect of root of lung. Pleura and lung cover it antero-laterally in superior mediastinum.

Left recurrent nerve arises as vagus crosses aortic arch; turns round below arch, on left side of attachment of lig. arteriosum; reaches groove between trachea and œsophagus, in which it ascends to neck. As it lies in groove, the arch is anterior to it and to its left, below; subclavian artery is first anterior and then on its left side; and common carotid is anterior at thoracic inlet. It gives branches to deep cardiac plexus as it hooks round aorta, and branches to trachealis muscle and œsophagus as it ascends in groove.

Cardiac Nerves.—Cervical cardiac branches of right vagus, and cervical cardiac branches of right sup., middle and inf. cervical sympathetic ganglia, having crossed the right subclavian artery, are joined by cardiac branches of right recurrent n., and all pass downwards and medially, behind innominate art., to the trachea, upon which they descend to deep cardiac plexus on its bifurcation. Cervical cardiac branches of left vagus and sympathetic enter thorax and run down, anterior to subclavian artery. The superior branch of sympathetic and inferior branch of vagus accompany phrenic and vagus across aortic arch, and end in superficial cardiac plexus; the others reach the trachea between subclavian and carotid arteries, and descend upon it to deep cardiac plexus, which is joined also by branches of left recurrent n. and thoracic cardiac branches of right vagus.

Thoracic duct emerges from posterior aspect of œsophagus and ascends on its left border. Longus colli is posterior to it. Aortic arch is anterior and on its left, below. Pleura is on its left and subclavian artery is anterior, above. **Right lymphatic duct** or **broncho-mediastinal trunk**, exceedingly slender, begins at 5th thoracic vertebra, and ascends into neck upon right longus colli.

Relations in Posterior Mediastinum

Note.—Some of the structures are described also in the part of their course outside mediastinum.

Descending thoracic aorta begins, as a continuation of aortic arch, at left side of lower border of 4th TH. vertebra, and ends, in the median plane, by passing through aortic opening of diaphragm and becoming continuous with abdominal aorta, opposite fibro-cartilage between 12th thoracic and 1st lumbar vertebrae.

Branches : 9 pairs of intercostals, 1 pair of subcostals, superior phrenics, 2 left bronchial, 1 right bronchial sometimes, 4 or 5 œsophageal, a few pericardial and mediastinal.

Relations. —*Anterior to it*, from above downwards, are : (1) root of left lung ; (2) pericardium, separating it from left atrium ; at same level the left lig. pulmonale is anterior to it, and below root of lung the left vagus, emerging from post. pulmonary plexus, crosses anterior to it to reach œsophagus ; (3) œsophagus and vagi, separating it from lower part of pericardium ; (4) diaphragm, separating it from omental bursa (lesser sac of peritoneum) and caudate (Spigelian) lobe of liver. *Posterior to it* are : (1) lower eight thoracic vertebrae and ant. longitudinal lig. ; (2) transverse parts of vena hemiazygos and v. hemiazygos accessoria (v. azygos minor inf. and sup.), opposite 8th or 9th vertebra ; (3) origins of intercostal and subcostal arteries ; (4) left pleura and lung, in its upper part, slightly.

On its left side are left pleura and lung, and close by it, more posteriorly and covered by pleura, are the vertical parts of hemiazygos veins and splanchnic nerves. *On its right side*, all the way, are thoracic duct and vena azygos, the duct being between vein and aorta. Anterior to duct and vein, the œsophagus is on right side of aorta, opposite 5th, 6th and 7th vertebrae ; below that, the œsophagus is anterior, and aorta is separated from right pleura and lung by fat and areolar tissue lying in front of thoracic duct and azygos vein.

Intercostal arteries for 9 lower spaces arise from dorsal aspect of descending aorta and extend laterally, over front and sides of vertebrae, towards intercostal spaces. Upper 4 or 5 pairs have to ascend to reach their spaces, because aorta begins only at lower border of 4th vertebra ; and those of right side are longer, because aorta begins on left side of vertebral column. Those of right side all pass behind thoracic duct and vena azygos, while the upper 5 are posterior to the accessory hemiazygos vein ; the lower 3 or 4, posterior to hemiazygos vein. On both sides, beyond the veins, they lie under cover of pleura, and the lower 6 are posterior to splanchnic nerves and their roots. Then each passes onwards, posterior to sympathetic trunk ; sends a **posterior branch** dorsally, medial to ant. costo-transverse

lig., to accompany posterior branch of spinal nerve ; crosses anterior to the intercostal nerve from below upwards, and passes laterally upon pleural aspect of ant. costo-transverse lig. and posterior intercostal membrane, with the vein above, the nerve below ; reaches angle of rib, where it slips in between ext. and int. intercostal muscles ; proceeds forwards in the costal groove, and anastomoses with a branch of int. mammary or, in case of 7th, 8th, 9th spaces, with a branch of musculo-phrenic ; while lowest two accompany intercostal nerves into abdominal wall, between obliquus internus and transversus abdominis, and anast. with subcostal, lumbar and epigastrics. Beyond angle of rib, each of upper 7 (*i.e.*, those in 3rd to 9th spaces) gives a **collateral branch**, which descends to upper border of rib below, and runs along it to anastomose with a branch of int. mammary or musculo-phrenic. Nearly midway between vertebral column and sternum each gives a **lateral cutaneous branch** to accompany lateral cutaneous nerve. Muscular branches are given off irregularly ; branches to mammary gland from upper 3 or 4 ; right bronchial artery from 1st.

Right subcostal artery passes laterally upon 12th vertebra, posterior to thoracic duct, vena azygos, splanchnic nerves, sympathetic trunk, pleura, and diaphragm ; and passes into abdomen, posterior to lateral lumbo-costal arch (ext. arcuate lig.) ; accompanies last thoracic n. along lower border of 12th rib, anterior to quadratus lumborum, posterior to kidney and upper end of ascending colon ; and, with the nerve, pierces the transversus abdominis, to lie between it and obliquus internus. **Left subcostal artery** differs in that it is posterior to v. hemiazygos instead of thoracic duct and vena azygos, and posterior to descending colon, instead of ascending colon.

Superior phrenic are small branches to post. part of diaphragm. **Œsophageal**, **pericardial**, and **mediastinal** are small irregular branches to œsophagus, post. part of pericardium, areolar tissue and lymph glands in posterior mediastinum.

Two **left bronchial arteries** arise from descending aorta, near its commencement, and run laterally and downwards to post. surface of left bronchus and accompany it into lung. One **right bronchial artery** arises from 1st right aortic intercostal after it has crossed œsophagus, and runs forwards, by right side of œsophagus, to post. aspect of right bronchus and follows it into lung. It may arise from upper left bronchial or from aorta.

Œsophagus enters post. mediastinum on right side of aorta ; remains on its right side opposite 5th, 6th, 7th TH. vertebrae ; then inclines forwards to lie on ant. surface of aorta, and before it passes through œsophageal opening in diaphragm, opposite 10th TH. vertebra, it is slightly to the left of aorta, but still on an anterior plane.

Anterior to it, from above downwards, are (1) left bronchus ; (2) right pulmonary artery ; (3) pericardium, separating it from left atrium ; (4) diaphragm. **Left vagus** emerges from post. pulmonary plexus as one or more cords which cross descending aorta and break up in

a plexus on ant. surface of œsophagus; from this a cord descends through œsophageal opening to break up on antero-superior surface of stomach. Lower edge of left pulmonary lig. is anterior to œsophagus, or the lig. may be attached to left side of œsophagus.

On left side of œsophagus are descending aorta above, left pleura and lung below. *On its right side* are right pleura and lung until it has come to lie anterior to aorta, where it is overlapped on the right by pericardium and diaphragm. *Posterior to it*, opposite 5th, 6th, 7th vertebræ, the thoracic duct and vena azygos ascend vertically, upper 5 right aortic intercostals cross, posterior to vein and duct. Below that level the aorta is posterior, and the lower end, which projects to the left of aorta, is supported posteriorly by pleura and lung. **Right vagus** emerges from post. pulmonary plexus as one or two cords which cross anterior to vena azygos and break up into a plexus on post. surface of œsophagus, from which a cord descends, through œsophageal opening, to postero-inferior surface of stomach. The œsophageal plexuses give branches to œsophagus and pericardium. Vena hemiazygos accessoria (v. az. minor sup.) may be high enough to be a posterior relation to œsophagus as it enters v. azygos.

Vena azygos arises either from post. aspect of inf. vena cava at level of renal vein, or from the right asc. lumbar vein, which is continuous with longitudinal anastomosis between right lumbar veins. It lies deep to inf. cava and right crus of diaphragm, on right side of cisterna (receptaculum) chyli; enters thorax through aortic opening of diaphragm, on right side of thoracic duct and aorta; runs upwards on vertebral column, and at level of 5th or 4th vertebra it arches forwards, above root of right lung, to end in superior cava. Its **tributaries**, which correspond fairly closely to branches of descending thoracic aorta, are œsophageal, pericardial, mediastinal, right bronchial, upper right lumbar, right subcostal, right intercostals from lower 8 spaces, right superior intercostal, which descends from 2nd and 3rd spaces and joins it where it begins to arch forwards; hemiazygos and accessory hemiazygos—conveying blood from left side, including lower 8 spaces—cross vertebral column to join it.

Relations of v. azygos in post. mediastinum.—The lower 8 TH. vertebræ, ant. longitudinal lig., right aortic intercostal and subcostal arteries are *posterior to it*; thoracic duct and descending aorta are *on its left side*, pleura and lung are *on its right*, and the right splanchnic nerves descend close to its right side, under cover of pleura. (Esophagus, with the vagi, is *anterior to it*, opposite 5th, 6th, 7th TH. vertebræ; below that it is overlapped by right pleura, and is covered by the fatty areolar tissue between right pleura and aorta; and, still lower down, it is behind diaphragm.

Vena hemiazygos (v. azygos minor inferior) arises from left ascending lumbar vein or from renal; enters thorax by piercing left crus of diaphragm; ascends upon bodies of lower TH. vertebræ, left subcostal and intercostal arteries, with splanchnic nerves descending

close to its left side, aorta close to its right. It is covered by pleura, antero-laterally, and is usually excluded from mediastinum while it ascends. At level of 8th or 9th vertebra it turns transversely to the right, posterior to aorta and thoracic duct, and ends in v. azygos. It receives blood from upper lumbar veins, left subcostal, 3 or 4 lower left intercostals.

Vena hemiazygos accessoria (v. azygos minor superior) descends along left side of bodies of 5th to 8th vertebrae and intercostal arteries, receiving left bronchial and 4th to 7th or 8th left intercostals. It is covered by pleura and has aorta on its right, upper roots of splanchnic nerve on its left. At 8th vertebra it turns to the right, posterior to aorta and thoracic duct, and ends in v. azygos. It communicates with left superior intercostal, and with hemiazygos vein.

Thoracic duct begins as a dilatation, about 2 inches long, called cisterna chyli (receptaculum), which lies on bodies of 1st and 2nd lumbar vertebrae and 1st and 2nd right lumbar arteries, overlapped by right crus; has aorta on its left, vena azygos on its right, and enters thorax through aortic opening of diaphragm, between these two. It ascends upon vertebral column, and at level of 5th thoracic vertebra it turns sharply to the left to ascend, in sup. mediastinum, upon left border of œsophagus.

In posterior mediastinum, descending aorta is to its left side throughout, and vena azygos to its right side. The right subcostal and aortic intercostal arteries and the ends of the hemiazygos veins separate it from ant. longitudinal lig. and vertebral bodies. Anterior to it are the œsophagus and vagi from 5th to 8th vertebrae; below that, the fatty tissue separating aorta from vena azygos and right pleura; and, lastly, the diaphragm.

Two lymphatic trunks, a right and a left, descend from lower intercostal lymph glands, cross the vena azygos and aorta superficially as they pass through aortic opening, and end in cisterna chyli.

PULMONES

Lungs.—Soft, spongy, pliable; float in water; exceedingly elastic, so that they shrink to $\frac{1}{3}$ when thorax is opened. Dark and mottled in adult, pink in early life. Pyramidal in shape.

Apex: rounded, lies at level of neck of first rib posteriorly; $1\frac{1}{2}$ to 2 inches above level of anterior end of rib, and $\frac{1}{2}$ to 1 inch above middle of sternal third of clavicle. Grooved by subclavian artery on medial and anterior aspects.

Base: semilunar in outline, concave; rests on diaphragm, which separates right lung from liver, left lung from liver, stomach and spleen.

Costal Surface.—Large and convex, passes imperceptibly

into thick, broad, rounded **posterior border**—the bulkiest part of lung—which occupies hollow at side of vertebral column.

Anterior border, shorter than posterior: begins at apex, curves downwards and medially, becomes sharp about an inch below apex, at back of sterno-clavicular joint. Shows a wide notch, *incisura cardiaca*, near lower end, on left lung, which leaves part of pericardium uncovered by lung. Mapped out on right side by same line as for pleura. On left side, in same way as pleura, down to 4th costal cartilage, below that by a line running along 4th cartilage for $1\frac{1}{2}$ inches, then curving, convex laterally and downwards, to 6th cartilage, 1 inch from median plane.

Medial Surface.—Divided into *vertebral area*, adapted to sides of bodies of vertebrae, and *mediastinal area*, in relation to mediastinal septum. Mediastinal area presents **hilum**, uncovered by pleura, where bronchi, pulmonary vessels, bronchial vessels, lymphatics, nerves enter and leave lung. Below hilum a thin strip, uncovered by pleura, extends to inferior border and marks attachment of lig. pulmonale. Below and anterior to hilum there is a hollow for heart and pericardium.

Inferior border limits base. Blunted where it separates base from mediastinal surface. Thin and sharp elsewhere, and falls considerably short of pleural reflection. Corresponds to line drawn from lower end of ant. border of lung to 6th cartilage in mid-clavicular line, thence backwards, almost horizontally, but slightly convex downwards, to 10th thoracic spine, crossing 8th rib in mid-axillary line, about 4 inches from lower margin of thorax, and crossing 10th rib in mid-scapular line.

Lobes and Fissures of Lung.—Left lung is cleft into 2 lobes by **oblique fissure**, which cuts into it as far as hilum and appears on all its surfaces. Begins about $2\frac{1}{2}$ inches below summit of apex, opposite 2nd thoracic spine: ends a little behind lower end of anterior border, behind 6th cartilage, a little medial to mid-clavicular line. **Lobus superior** includes apex and anterior border and greater part of mediastinal area. **Lobus inferior**, bulkier, includes almost whole base and greater part of posterior border.

Right lung is cleft by two fissures into 3 lobes. **Oblique fissure** resembles that of left, except that, ant. border of right lung being straighter, it ends further away from its lower end. **Transverse fissure** begins at ant. border, behind 4th

costal cartilage; extends laterally and slightly upwards to meet oblique fissure about its middle, opposite mid-axillary line. **Lobus inferior** includes less of base than on left side. **Lobus superior** is smaller than in left lung, owing to wedge-shaped **lobus medius**, which is cut off from it, and includes lower part of ant. border and greater part of pericardial hollow.

Differences between Right and Left Lung.—Right lung, tri-lobed; larger in ratio of 11 to 10. Shorter, owing to upward projection of liver; wider, because heart projects less to right side. Base more concave, because of liver; pericardial hollow shallower; cardiac notch absent. Different markings on medial surfaces.

Arteries of Lungs.—Pulmonary convey blood for aëration. Bronchial supply lung substance, and their blood is returned partly by bronchial and partly by pulmonary veins. **Lymphatics** end in broncho-pulmonary glands. **Nerves**, from vagus and sympathetic, through pulmonary plexuses.

Relations of Medial Surface of Lung and Mediastinal Pleura

Pleura intervenes between lung and structures mentioned below: *i.e. the structures exposed by removal of lung, pleura (and pericardium) in a dissection of thorax from the side.*

On both sides the **vertebral area** is related to intercostal vessels, roots and trunks of splanchnic nerves, and *on left side*, in addition, to vertical parts of vena hemiazygos and v. hemiazygos accessoria.

Mediastinal Area.—*On right side* the pericardial hollow is in relation to heart, pericardium, phrenic nerve and pericardiaco-phrenic vessels. Portions of heart in relation are right atrium and auricle and part of right ventricle. A groove extends upwards from pericardial hollow; another vertical groove lies posterior to hilum and upper part of lig. pulmonale; a narrow, sharply-cut horizontal groove, just above hilum, connects the two. The groove extending upwards from pericardial hollow lodges phrenic nerve and pericardiaco-phrenic vessels, right innominate vein and sup. vena cava, lower end of which is, however, inside pericardium. The groove behind hilum and lig. pulmonale lodges œsophagus or vena azygos or both, and the strip below its lower end is separated from descending aorta by fatty areolar tissue. The horizontal groove is for arch of v. azygos, which here separates pleura and lung from trachea and vagus.

Above horizontal groove there is an area related to trachea, vagus, cardiac nerves, and œsophagus; and at upper part of this area is the beginning of groove for subclavian artery, which passes laterally on ant. surface, below apex. Area anterior to groove for sup. v. cava

overlaps ascending aorta below, thymus and termination of left innominate vein above. Anterior to lower end of lig. pulmonale there is a notch for small thoracic part of inf. v. cava and lower end of phrenic nerve and its accompanying vessels.

On left side the pericardial hollow is related to phrenic n. and accompanying vessels, pericardium and heart. Portions of heart in relation are left ventricle inferiorly, left atrium and auricle above and posteriorly, conus arteriosus of right ventricle above and anteriorly. Above that, anterior to hilum, there is an impression for pulmonary arterial trunk, and, anterior to that, there is an area which overlaps lower end of thymus and upper part of ascending aorta.

Posterior to lower end of lig. pulmonale there is a notch for oesophagus. Broad groove behind lig. pulmonale and hilum is for descending aorta; and it is continuous with broad horizontal groove, just above hilum, in relation to aortic arch, vagus phrenic, two cardiac nerves, left sup. intercostal vein. Anterior to level of root of lung the groove is either faint or absent, as arch is separated there by fatty tissue and thymus. From ant. part of horizontal groove, in line with ant. surface of lung root, a narrow, clean-cut groove runs vertically upwards, and lodges subclavian artery. Area anterior to this subclavian groove is related to thymus, left carotid art., vagus, phrenic and cardiac nerves; area posterior to it is related to recurrent n., oesophagus, and thoracic duct.

Relations of Cervical Pleura and Apex of Lung

Immediate Relations. Cupola of pleura is supported *inferiorly* by lung and separates it from structures mentioned below.

Sibson's fascia, spreading from 7th C. transverse process to inner margin of 1st rib, is the closest relation of pleura on antero-lateral aspect. Scalenus medius supports it laterally, and scalenus anterior antero-laterally.

Vessels.—Subclavian art. arches laterally across ant. aspect of pleura, below apex; on left side it ascends on medial aspect before doing so. Int. mammary descends from it, vertebral art. and thyro-cervical trunk (thyroid axis) ascend from it, all on ant. aspect of pleura; costo-cervical trunk runs up to apex and its sup. intercostal branch turns downwards, posterior to apex. Innominate art. is antero-medial, on right side, and is separated by fatty areolar tissue.

Int. jugular vein descends anterior to pleura and subclavian art.; vertebral vein is posterior to jugular. Vein from 1st intercostal space arches forwards over apex of pleura and joins vertebral, or turns down between pleura and subclavian art. to join innominate. Subclavian vein is separated from pleura by scalenus anterior, but on left side it ends on pleura, medial to scalenus. Innominate vein is below subclavian art., and between vein and pleura are phrenic n. and int.

mammary art. ; on right side the vein passes over rounded ant. margin of upper part of pleura and lung on to medial surface.

Thoracic and right lymphatic ducts, on left and right sides respectively,—each ascends into neck between œsophagus and medial surface of pleura, arches laterally behind carotid sheath at higher level than pleura, turns downwards anterior to subclavian art. and pleura, lateral to int. jugular, to join innominate vein.

Nerves.—Vagus and cervical cardiac branches of vagus and of sympathetic descend medial to int. jugular, on ant. aspect of pleura, and pass on to its medial aspect ; phrenic nerve passes obliquely across int. mammary art., on ant. aspect of pleura, posterior to innominate vein, and turns over blunted ant. border on to medial aspect ; ansa subclavia loops round subclavian art. medial to int. jugular, anterior to pleura ; on right side the recurrent n. also hooks round. Sympathetic trunk and 1st thoracic nerve are posterior to apex, on neck of 1st rib, the nerve being lateral to the trunk, and between them are sup. intercostal art. and companion vein.

Viscera.—Trachea and œsophagus are medial to each apex, separated by fatty areolar tissue in which, on right side, are vagus, cardiac nerves and right lymphatic duct ; on left side, the phrenic, vagus, cardiac nerves, carotid and subclavian arteries and thoracic duct. Lymph glands lie in relation to vessels on all aspects.

More Remote Relations.—Medial $\frac{1}{3}$ of clavicle, sterno-mastoid, sterno-hyoid and sterno-thyreoid. These conceal cervical pleura and the structures in front of it. Ant. jugular vein runs laterally just above clavicle, between sterno-mastoid and the other two muscles.

RADIX PULMONIS

Root of lung consists of pulmonary art., two pulmonary veins, bronchus, bronchial art. and veins, lymph vessels and glands, pulmonary nerves.

Relations of these to one another.—*From before backwards* : upper pulmonary vein, pulm. art., bronchus ; and bronchial vessels are on post. aspect of bronchus. *From above downwards, on right side* : eparterial bronchus, artery, hyparterial bronchus, lower vein ; *on left side* : artery, bronchus, lower vein.

Relations of Whole Root.—**Right side** : *Anterior* : v. cava superior, phrenic nerve, ant. pulmonary plexus. *Superior* : v. azygos. *Posterior* : post. pulmonary plexus. *Inferior* : lig. pulmonale.

Left side.—*Anterior* : phrenic nerve, ant. pulmonary plexus. *Superior* : aortic arch. *Posterior* : descending aorta, post. pulmonary plexus. *Inferior* : lig. pulmonale.

DIGESTIVE APPARATUS

ALIMENTARY CANAL. DIGESTIVE GLANDS. ACCESSORY PARTS.

Alimentary canal consists of : — (1) *Mouth*, (2) *isthmus faucium*, (3) *pharynx*, in the head and neck ; (4) *oesophagus* begins in neck, traverses thorax and ends in abdomen ; (5) *stomach*, (6) *small intestine*, (7) *large intestine* occupy abdomen and pelvis. Small intestine is subdivided into duodenum, jejunum, ileum. Large intestine is subdivided into caecum with vermiform process, ascending colon, right colic (hepatic) flexure, transverse colon, left colic (splenic) flexure, descending colon, iliac colon, pelvic colon, rectum and anal canal.

Digestive glands are (1) the *salivary* — parotid, sub-maxillary, sublingual ; (2) *liver*, (3) *pancreas* ; besides (4) small glands in walls of all parts of alimentary canal.

Accessory parts are *teeth*, *gums*, *palate*, *tongue*, *tonsils*, *peritoneum*.

CAVUM ORIS

Mouth consists of vestibule and cavity proper.

Vestibulum oris is the space between lips and cheeks on the one hand, and teeth and gums on the other. Communicates with cavity proper through opening behind last molar tooth. Behind that opening the coronoid process and tendon of temporal muscle may be felt ; and lateral to it, the ant. edge of masseter. Parotid duct opens into vestibule, opposite second upper molar ; and numerous small glands open into vestibule. In median plane, mucous mem-

brane is raised, between lips and gums, as folds called *frenulum labii superioris* and *frenulum labii inferioris*.

Lips consist of:—(1) Skin; (2) superficial fascia; (3) orbicularis oris; (4) submucous tissue, with vessels and labial mucous glands, palpable by the tongue; (5) mucous membrane, covered with stratified squamous epithelium.

Philtrum is the vertical groove in middle of upper lip.

Arteries.—Infra-orbital and sup. labial (coronary) to upper lip; inf. labial, mental and submental to lower lip. **Nerves.**—Branches of facial supply muscles; infra-orbital, buccinator (long buccal) and mental branches of trigeminal supply skin and mucous membrane. **Lymphatics** of both lips end in submaxillary glands; from median part of lower lip, in submental glands.

Buccæ (Cheeks) resemble lips. (1) Skin. (2) Superficial fascia, containing the zygomaticus, risorius, platysma muscles; parotid duct, surrounded by mucous *molar glands*; vessels, and branches of facial and trigeminal nerves. (3) Buccinator, covered with the bucco-pharyngeal fascia, and pierced by parotid duct. (4) Submucosa, with *buccal glands*. (5) Mucous membrane.

Corpus adiposum buccæ (sucking pad) is encapsuled mass of fat lying on buccinator and passing under masseter. Relatively larger in child. Assists cheek to resist atmospheric pressure during sucking.

Arteries.—Transverse facial, buccinator, mental, infra-orbital; ext. maxillary (facial) and some of its branches. **Lymphatics** from ant. part of cheek end in submaxillary glands, from posterior part in anterior auricular and parotid glands. **Nerves.**—Branches of facial to muscles. Zygomatico-facial and infra-orbital branches of maxillary n., buccinator and mental branches of mandibular, to skin and mucous membrane.

Cavum Oris Proprium.—Cavity proper of mouth: bounded *anteriorly* and *laterally* by teeth and gums; *superiorly* by hard and soft palate; *inferiorly* by tongue and “floor of mouth” or sublingual region. Opens *posteriorly*, through isthmus faucium, into pharynx.

Sublingual region is region below tip and sides of tongue. Anteriorly, the mucous membrane stretches across from side to side, covering sublingual glands and upper borders of genio-glossi. At sides of tongue it is reflected from upper part of mylo-hyoid on to stylo-glossus and upper part of

hyo-glossus, and covers lingual nerve as it enters sub-maxillary region. *Frenulum lingue*, a fold of mucous membrane in median plane, extending from floor of mouth to under surface of tongue. *Caruncula sublingualis*, a papilla on each side of frenulum at its attachment to floor; submaxillary duct Wharton opens on it. *Plica sublingualis*, a ridge running from caruncle laterally and posteriorly, produced by underlying sublingual gland, whose ducts open on the crest of the plica.

Lymphatics from floor of mouth end in lingual, sub-maxillary and submental glands; thence to deep cervical.

Hard palate consists of palatine processes of maxilla and horizontal parts of palatine bones, covered by periosteum, dense fibrous tissue and mucous membrane. Greater palatine art. and nerve run forwards in the fibrous tissue near alveolar margin; naso-palatine nerves enter it behind incisor teeth. Numerous mucous palatine glands lie in posterior part of submucous tissue.

Velum palatinum (Soft palate) projects downwards and backwards, as a movable fold, from hard palate almost to post. wall of pharynx, blending laterally with side walls of pharynx.

Structures forming soft palate. passing from pharyngeal to oral surface, are: (1) mucous membrane; (2) upper layer of pharyngo-palatinus; (3) musculus uvulae, near median plane; (4) levator veli palatini; (5) lower layer of pharyngo-palatinus; (6) tensor v. palatini and palatine aponeurosis; (7) glosso-palatinus; (8) thick layer of mucous glands; (9) mucous membrane.

Uvula, a median projection from free edge of soft palate, consists of musculus uvulae surrounded by mucous membrane.

Arteries of Palate—Greater palatine, ascending palatine, ascending pharyngeal. *Lymphatics* end in parotid and deep facial glands, and thence to deep cervical glands. *Nerves*: *Motor*, to tensor from otic ganglion; to others from pharyngeal plexus (ultimately from accessory). *Sensor*, palatine and naso-palatine branches of sphenopalatine ganglion, glosso-pharyngeal.

Isthmus faucium is the communication between mouth and pharynx. Bounded above by soft palate, below by tongue, on each side by *arcus glosso-palatinus* (ant. pillar of fauces), a fold of mucous membrane which extends from oral surface of soft palate, near base of uvula, to middle of side of tongue, and encloses glosso-palatinus muscle. Posterior to the arch lies the palatine tonsil.

LINGUA (TONGUE)

Body of tongue is subdivided by median fibrous septum into symmetrical halves, composed of: (1) **Muscles**—*extrinsic*: genio-glossus, hyo-glossus, stylo-glossus, glosso-palatinus; *intrinsic*: superior and inferior longitudinal, vertical, transverse. (2) Finely divided fat, among muscles. (3) **Glands**—*mucous*, at sides and back; *serous*, near vallate papillæ; *sero-mucous* (anterior lingual), among muscles on inferior surface, near apex.

Dorsum linguæ, covered with mucous membrane. Divided into two: (1) **Pharyngeal part** looks backwards into pharynx; covered with smooth mucous membrane, studded with pitted nodules produced by underlying lymphoid follicles, collectively named *tonsilla lingualis*; connected with epiglottis by median glosso-epiglottic fold. (2) **Oral part** looks towards palate; separated from pharyngeal part by V-shaped *sulcus terminalis*, limbs of which are directed anteriorly and laterally, towards glosso-palatine arch, from a median pit at apex of V, called *foramen cæcum*, which represents upper end of thyreo-glossal duct. Mucous membrane of oral part is roughened by papillæ of various kinds.—*See next page.*

Apex and lateral margins, anterior to glosso-palatine arches, are free and in contact with teeth.

Inferior surface of free part of tongue is covered with smooth mucous membrane and is connected with floor of mouth by frenulum linguæ. On each side, profunda vein (ranine) can be seen through mucous membrane. More laterally is a fringed fold, called *plica fimbriata*, under which the profunda art. (ranine) lies.

Radix linguæ is the fixed part connected by muscles and mucous membrane to hyoid bone, mandible, pharynx, epiglottis and palate.

Arteries of Tongue.—Lingual—chiefly. Branches also from tonsillar of ext. maxillary and asc. pharyngeal. Very little anastomosis across median plane. **Lymphatics**: from tip, to submental glands; from sides and middle, through lingual glands, to submaxillary and upper deep cervical glands; from base, to upper deep cervical. One of deep cervical, lying deep to posterior belly of digastric, receives most of lymph vessels of tongue.

Nerves.—Hypoglossal, to intrinsic and extrinsic muscles, except glosso-palatinus. Lingual (common sensory), including

chorda tympani (taste), to ant $\frac{2}{3}$. Glosso-pharyngeal (common sensory and taste), to post. $\frac{1}{3}$. A few branches from laryngeal (common sensory) to dorsum, near epiglottis.

Papillæ of Tongue.—(1) *P. vallatæ*, about 10 in number, arranged in form of V, anterior and parallel to sulcus terminalis. Each is a short cylinder surrounded by circular trench, outer wall of which is raised up as a collar. Serous glands open into trench, and taste buds lie in its walls. (2) *P. fungiformes* (et lenticulares), more numerous; bright red in living subject; furnished with taste buds; consist of rounded head attached by narrower base; found chiefly at apex and margins. (3) *P. conicæ et filiformes*, in great numbers, arranged in rows parallel to s. terminalis posteriorly, transverse and then irregular anteriorly. (4) *P. foliatæ*, 5 or 6 vertical folds, studded with taste buds, on margins of tongue, anterior to glosso-palatine arches.

TEETH AND GUMS

Each **tooth** consists of a **crown**, covered with adamantina (enamel); **neck**, surrounded by gum; **root**, imbedded in jaw. Each encloses a **cavity** containing **pulp**, composed of connective tissue, vessels and nerves, which enter through *foramen in apex* of root. Crown is chisel-shaped in *incisor* teeth, conical in *canine*; has 2 tubercles (cusps) in *premolar*, a larger labial and smaller lingual; 3 or 4 tubercles in upper *molars*, 4 or 5 in lower molars.

Deciduous Teeth (Milk Teeth).—2 incisors, 1 canine, 2 molars, in each half of each jaw. *Medial upper is the largest of incisors*. Incisors and canine have single roots. Roots of upper molars are divided into three fangs, of lower into two. Distinguished from permanent teeth by small size, constricted necks, and, in the case of molars, by wide divergence of fangs. **Periods of eruption**: very variable; lower set precedes upper. Begins between 6th and 9th month after birth, completed about 24th month. Appear in following order: medial incisors, lateral incisors, first molars, canines, second molars.

Permanent Teeth.—2 incisors, 1 canine, 2 premolars, 3 molars. Premolars replace deciduous molars. Permanent molars are not represented in deciduous dentition. As in case of deciduous teeth the upper medial incisor is largest of incisors and lower medial is smallest, with the result that teeth of the two jaws are not directly opposite, but each tooth of upper jaw touches two of lower teeth, except 3rd upper molar, which touches only 3rd lower molar, and, being smaller, it does not extend further back than lower molar.

Roots of incisors, canines, lower and 2nd upper premolars are single. Root of 1st upper premolar is bifid. Roots of canine teeth

are longer than those of others. Roots of upper molars are divided into three parts, two lateral, one medial; of lower molars into two, anterior and posterior, and each of these may be bifid at apex.

Periods of Eruption.—1st molar about 6th year; medial incisors, 7th; lateral incisors, 8th; 1st premolar, 9th; 2nd premolar, 10th; canine, 11th; 2nd molar, 12th; 3rd molar, *dens serotinus* (wisdom tooth), 17th to 25th year.

Vascular and Nerve Supply.—**Maxillary teeth** are supplied by superior alveolar branches of int. maxillary art. and its infra-orbital branch; sup. alveolar branches of maxillary nerve and its infra-orbital branch; and their lymph vessels end in submaxillary or ant. auricular glands. **Mandibular teeth**, by inf. alveolar branch of int. maxillary art. and mandibular nerve, and their lymph vessels end in submaxillary and upper deep cervical glands.

Gingivæ (Gums) are attached to alveolar margins of jaws; surround necks of teeth. Consist of dense but vascular fibrous tissue, covered with mucous membrane.

Blood-vessels and Nerves.—**Outer upper gum**: superior alveolar and infra-orbital. **Inner upper gum**: superior alveolar and greater palatine vess. and n. and naso-palatine n. **Outer lower gum**: lower inferior labial, inf. alveolar and mental vess. and small branches of ext. maxillary; mental and inf. alveolar nerves. **Inner lower gum**: lingual, sublingual, mylohyoid vess., inf. alveolar and its lingual branch; lingual and inf. alveolar nerves.

Lymph vessels from anterior part of outer mandibular gum end in submental glands; from inner maxillary gum, in upper deep cervical; from the remainder, in submaxillary lymph glands.

SALIVARY GLANDS

PAROTID. SUBMAXILLARY. SUBLINGUAL.

Parotid Gland.—Largest of the three; lies in *parotid recess* below ear, posterior to mandible, enveloped in sheath prolonged from cervical fascia. Extends superficially up to zygomatic arch, downwards beyond angle of mandible, forwards over masseter as **facial process**, upper part of which may be isolated and called **accessory parotid** (*socii parotidis*).

Shaped like an inverted and irregular 3-sided pyramid. Concave *base* fits against cartilaginous meatus and lateral part of bony meatus, its sharp anterior margin being wedged between meatus and mandibular joint. *Apex* projects downwards over post. belly of digastric, and overlaps carotid

arteries and int. jugular vein in carotid triangle. Flat, superficial or *lateral surface* is related to (1) skin ; (2) superficial fascia, fibres of posterior part of platysma, branches of great auricular n. ; (3) parotideo-masseteric fascia and ant. auricular lymph glands. Concave, *antero-medial surface* is related to post. borders of masseter, mandibular ramus and lower part of pterygoideus int., and is separated from submaxillary gland by stylo-mandibular lig. Irregular, *postero-medial surface* is grooved by (1) ant. borders of mastoid process and sterno-mastoid ; (2) post. belly of digastric and post. auricular art. ; (3) styloid process and stylo-hyoid muscle.

In its substance are (1) ext. carotid art. ; (2) post. facial vein ; (3) facial nerve and its communications from great auricular and auriculo-temporal ; (4) some parotid lymph glands.

Parotid Duct arises from facial process ; runs anteriorly upon masseter, at anterior border of which it turns sharply medially, through fat of cheek, and pierces buccinator ; runs anteriorly for $\frac{1}{2}$ in. and pierces mucous membrane, opposite 2nd upper molar. It is accompanied by branches of facial nerve. Transverse facial vessels and accessory parotid are above it.

Position is indicated by middle $\frac{1}{3}$ of line drawn from lower margin of ext. acoustic meatus to midway between ala of nose and red margin of lip.

Above angle of mandible the border separating antero-medial and postero-medial surfaces of parotid gland is sometimes prolonged forwards, between ramus of mandible and pterygoideus internus, as the **pterygoid lobe**. Ext. carotid art., ascending from under cover of digastric and stylo-hyoid, comes into relation with postero-medial surface of parotid, gives off post. auricular art., and pierces base of pterygoid lobe, passing from postero-medial surface to antero-medial surface, to reach post. aspect of neck of mandible, where it divides into int. maxillary and superficial temporal. Int. maxillary passes under cover of mandible. Superficial temporal gives off transverse facial and appears at upper end of parotid, in front of auricle. Transverse facial appears at ant. border, above duct. Occipital and post. auricular run upwards and posteriorly, deep to parotid, in relation to lower and upper borders of digastric, respectively.

Posterior facial vein descends over zygoma, in front of auricle ; slips under cover of antero-medial surface of parotid ; receives transverse facial and int. maxillary veins ; passes through parotid, superficial to ext. carotid ; gives off a branch which emerges from postero-medial surface, at lower end, and joins post. auricular to form ext. jugular ;

and post. facial itself emerges from lower end, and runs downwards and anteriorly to join anterior facial.

Auriculo-temporal n. runs laterally, behind mandibular joint, above parotid, and appears in front of ear, behind superficial temporal artery.

Facial nerve enters parotid on postero-medial surface, between impressions for styloid and digastric; breaks up, superficial to post. facial vein, into branches which are joined by branches from auriculo-temporal and great auricular; and most emerge on antero-medial surface. Temporal branches appear at upper end of parotid; zygomatic, buccal, and marginal mandibular branches appear at ant. border; ramus colli (cervical branch) emerges from postero-medial surface at lower end.

In relation to postero-medial surface, on deeper plane than digastric, stylo-hyoid and styloid process, are the stylo-pharyngeus, ext. and int. carotids, int. jugular, and last 4 cerebral nerves.

Arteries to Parotid: ext. carotid, post. auricular, int. maxillary, superficial temporal, transverse facial. **Lymphatics** pass through ant. auricular and parotid lymph glands to superficial and upper deep cervical glands. **Nerves:** *sensory*, from great auricular and auriculo-temporal; *secretory*, from auriculo-temporal; *vasomotor*, from sympathetic plexus around ext. carotid.

Submaxillary Gland (see also p. 223) lies ensheathed in fascia, between bellies of digastric (which it overlaps), on hyoglossus and mylo-hyoid, below mucous membrane of mouth, under cover of mandible and pterygoideus internus, and supported inferiorly by skin, fasciæ, and platysma. Ext. maxillary art. (facial) is lodged in groove on post. part of medial surface. **Submaxillary duct** arises from medial surface and, accompanied by deep process of gland, passes forwards, superficial to hyo-glossus and genio-glossus, deep to mylo-hyoid and sublingual gland, and opens at side of frenulum linguæ.

Sublingual Gland (see also p. 224).—Smallest salivary gland. Lies above mylo-hyoid, between genio-glossus and mandible near symphysis, under plica sublingualis in floor of mouth, upon which its ducts (8-20) open.

PHARYNX

Pharynx lies posterior to nose, mouth, and larynx, and communicates freely with them, as it has no proper anterior wall. Extends from base of skull to 6th c. vertebra, where, at level of lower border of cricoid, it is continuous with œsophagus. Upper end is about level of zygoma and of

junction of nasal bone with cartilage. *Attached superiorly* to basi-occipital and petrous temporal; *anteriorly*, from above downwards, to auditory tube (Eustachian); medial pterygoid lamina; pterygo-mandibular raphe; mylo-hyoid line, and mucous membrane of mouth; base of tongue and hyoid bone; thyreoid and cricoid cartilages.

Cavity of pharynx is divided into nasal, oral, and laryngeal parts, and is widest in nasal part.

Nasal part (naso-pharynx) is placed posterior to cavity of nose, above soft palate. Belongs not to digestive but to respiratory tract. It communicates with oral pharynx through oblique interval between palate and back of pharynx, called **isthmus pharyngo-nasalis**, which is sometimes very constricted.

Floor (the soft palate), movable; other walls, rigid. *Anteriorly* it communicates with nasal cavities through **choanæ**. *Lateral wall* measures a little over 1 inch each way; presents, about its centre, the **ostium pharyngeum** of auditory tube (Eustachian), on a level with and $\frac{1}{2}$ inch behind inf. nasal concha (inf. turbinated). Opening is guarded superiorly and posteriorly by prominence, called **torus tubarius** (Eustachian cushion), from which the **plica salpingo-pharyngea**, enclosing salpingo-pharyngeus muscle, extends downwards, and is gradually lost on wall of pharynx below. Posterior to torus is a gap leading into narrow **pharyngeal recess**, which extends laterally for $\frac{1}{2}$ inch between auditory tube and prevertebral muscles, above upper edge of sup. constrictor, below foramen lacerum and petrous temporal. *Roof and posterior wall* form continuous slope, opposite posterior part of body of sphenoid, basi-occiput and anterior arch of atlas; **pharyngeal tonsil** and **bursa pharyngea**, in this wall, are well marked in child, but small or absent in adult. (The bursa is a small median diverticulum of mucous membrane.)

Oral Part of Pharynx.—Posterior to tongue and mouth; communicates with the mouth through isthmus faucium. Common to respiratory and digestive systems. *On lateral wall* the **pharyngo-palatine arch** (post. pillar of fauces), a fold of mucous membrane enclosing pharyngo-palatinus, arches downwards and posteriorly from edge of soft palate, and is lost on side wall of pharynx. It forms lateral boundary of isthmus pharyngo-nasalis (naso-pharyngeal isthmus).

Palatine tonsil occupies triangular space above tongue, below soft palate, between glosso-palatine and pharyngo-

palatine arches. Lies opposite a point, on surface of face, $\frac{1}{2}$ inch above and in front of angle of mandible. Consists of an oval mass of lymphoid tissue, encapsuled in fascia connected with pharyngeal aponeurosis. Pharyngeal surface is covered with mucous membrane, in which is a number of pits, called *fossulae tonsillares* or *crypts*. *Supra-tonsillar fossa* is a recess above tonsil. Lateral surface is related to sup. constrictor, which separates it from asc. palatine and from ext. maxillary (facial) arteries.

Arteries to tonsil, from asc. palatine, tonsillar, asc. pharyngeal, dorsalis linguæ. *Lymphatics* end in upper deep cervical glands on int. jugular vein, opposite angle of mandible. *Nerves*: special branch from glosso-pharyngeal; branches from pharyngeal plexus.

Laryngeal part of pharynx lies posterior to larynx. Upper part is common to digestive and respiratory tracts. Lower part (narrowest part of pharynx), opposite cricoid, belongs to digestive system alone, and its ant. and post. walls are in contact, except when food is passing. *Anterior wall* presents epiglottis, arytenoids, sup. aperture of larynx, ary-epiglottic folds, recessus piriformis and cricoid.—See *Larynx*, p. 417.

Pharynx is separated *posteriorly* from longi capitis and colli, and recti anteriores, by retro-pharyngeal areolar tissue. Related *laterally* to styloid process and its muscles; common, ext., and int. carotid, sup. thyreoid, asc. pharyngeal, lingual, ext. maxillary, asc. palatine and tonsillar arteries; lingual, glosso-pharyngeal, int. and ext. laryngeal nerves, pharyngeal branches of vagus and sympathetic; posterior belly of digastric, pterygoideus internus.

Walls of pharynx consist of: (1) bucco-pharyngeal fascia, in and under which are pharyngeal plexuses of veins and nerves; (2) constrictors and pharyngo-palatinus, stylo-pharyngeus, salpingo-pharyngeus; (3) pharyngeal aponeurosis; (4) mucous membrane, in which are many mucous glands and much lymphoid tissue, a special aggregation of which, called **pharyngeal tonsil**, is situated at roof of pharynx.

Arteries to Pharynx.—Asc. pharyngeal, asc. palatine, tonsillar, post. palatine, dorsalis linguæ, pharyngeal and art. of pterygoid canal from int. maxillary. *Lymphatics* end in retro-pharyngeal and deep cervical glands. *Nerves*: pharyngeal plexus; int. laryngeal to back of larynx; pharyngeal branch from spheno-palatine ganglion to roof of pharynx.

ŒSOPHAGUS

Œsophagus is 8-14 in. long ; average 10. Extends from end of pharynx, opposite 6th C. vertebra and lower border of cricoid, through lower part of neck, sup. and post. mediastina ; pierces diaphragm opposite lower part of 10th TH. vertebra and enters stomach opposite 11th, 4 in. behind 7th costal cartilage, 1 in. to left of median plane. *On the back*, commencement is opposite 6th C. spine. Crossed by left bronchus in thorax, opposite 4th TH. spine. Ends opposite 10th spine.

Distance from incisor teeth to commencement is 6 in. ; to left bronchus 9-10 in. ; to termination 16 in.

Slightly constricted at beginning, and at diaphragm, and where left bronchus crosses it.

Direction is curved in conformity with vertebral column, and it deviates to the left of median plane in neck and upper part of thorax, and again at lower part of thorax.

Relations (see also pp. 210, 429, 432).—*Anterior* : from above downwards, trachea and recurrent nerves, left bronchus, right pulmonary art., pericardium, diaphragm. *Posterior* : separated from vertebral col., and ant. longitudinal lig. by longi colli in neck and sup. mediastinum ; by upper 5 right aortic intercostal arteries, v. azygos, thoracic duct and aorta, in post. mediastinum. *Right side* : carotid sheath and thyroid gland, in neck ; arch of v. azygos, pleura and lung, in thorax. *Left side* : carotid sheath, thyroid gland and thoracic duct, in neck ; thoracic duct, subclavian art., pleura and lung and aortic arch, in sup. mediastinum ; descending aorta, and lower part of left pleura and lung, in posterior mediastinum.

Note.—In post. mediastinum, left vagus breaks up into a plexus on ant. surface of œsophagus, right vagus on its post. surface.

Abdominal Part of Œsophagus.— $\frac{1}{2}$ inch or less. Covered anteriorly and on left with peritoneum, has left crus of diaphragm behind, inf. phrenic art. intervening ; is separated from œsophageal groove of liver by lip of hiatus œsophageus of diaphragm.

Walls of Œsophagus.—*Muscular coat* :—Striped fibres at upper end only. External longitudinal layer attached to cricoid above, continuous with longitudinal fibres of stomach below. Internal circular layer continuous with inferior constrictor above, with circular and oblique coats of stomach below. *Submucous coat* contains many mucous glands. *Mucous membrane* is covered with stratified squamous epithelium.

Arteries : from inf. thyroid, bronchial, descending aorta, left gastric and inf. phrenic. **Veins** form plexus on surface, drained chiefly into systemic, but at lower end into portal system. **Lymph-**

atics end in para-tracheal, lower deep cervical, bronchial, post. mediastinal and para-cardial glands. **Nerves:** from recurrent, sympathetic trunks, and vagi.

ABDOMEN

Abdomen contains remaining parts of digestive apparatus, and is subdivided into abdomen proper and pelvis.

Walls of its cavity are lined with serous membrane, called **peritoneum**, which provides partial or complete coverings for most of the abdominal viscera also, forming free folds in connection with some of them. Between peritoneum and the fascia lining the muscles of abdomen wall, there is some loose connective tissue, called *tela subserosa* or *extra-peritoneal tissue*. It contains fat, especially on posterior wall of abdomen proper, in pelvis, and in peritoneal folds, into which it extends to reach viscera. Fat is absent from part of diaphragm covered with peritoneum.

Abdomen proper includes the part supported by osseous pelvis major, and its upper part lies under shelter of ribs. It is *bounded superiorly* by diaphragm, which during expiration reaches highest on right side, opposite 4th intercostal space, 1 in. medial to nipple; on left side, $\frac{1}{2}$ in. below that level; *anteriorly* by recti and aponeuroses of obliqui and transversi abdominis; *laterally* by fleshy parts of obliqui and transversus, and by ilium and iliacus on each side; *posteriorly* by lumbar vertebræ, erura of diaphragm, psoades, quadrati lumborum.

Cavity of abdomen proper is divided into three zones, *costal*, *umbilical*, *hypogastric*, by two horizontal planes: (1) *subcostal*, which passes below most dependent parts of 10th ribs and through 3rd L. vertebra; (2) *intertubercular*, which passes through tubercles on crests of ilia, *i.e.* highest points of crests **seen from the front**, and through 5th L. vertebra. Zones are each divided into three regions by *right* and *left lateral* planes, drawn upwards from inguinal lig. (Poupart), midway between symphysis pubis and ant. sup. iliac spine. Costal zone = *epigastrium*, *right* and *left hypochondrium*. Umbilical zone = *umbilical*, *right* and *left lumbar regions*. Hypogastric zone = *hypogastric* or *supra-pubic*, *right* and *left iliac regions*.¹

Another plane described is the **transpyloric plane**, which passes horizontally through mid-point between upper margins of sternum and of symphysis pubis. It is about a hand's-breadth below xiphisternal

¹ The conventional method of subdividing the abdomen into nine regions, and of describing organs as lying in certain of these regions, tends rather to encumber the memory than to assist in localising these organs; and it has been retained here only because it has not yet been abandoned in the standard text-books.

junction ; and it cuts the pylorus of stomach, the lower margin of liver at median plane, the kidneys above the middle of their hila, neck of pancreas, origin of sup. mesenteric art., and the 1st L. vertebra.

Pelvis is bounded by bones and ligaments of pelvis minor, and by transversus perinæi profundus and sphincter urethræ *anteriorly* ; obturator internus *laterally* ; piriformes and coccygei *posteriorly*. Levatores ani form a partition separating pelvic cavity proper from ischio-rectal fossæ.

Relations of organs in abdomen are exceedingly variable, not only in different subjects, but in the same subject at different periods of life. They vary also from hour to hour, owing to changes in posture of the body and to varying degrees of distension of hollow viscera, while pendulum-like variations occur with every inspiration and expiration. Relations given are those which are considered to represent the average conditions found in dead adult subjects lying in the supine position.

VENTRICULUS GASTER

Stomach.—Most dilated part of alimentary canal ; lies in upper left quadrant of abdomen, in epigastrium and left hypochondrium. Piriform in shape. Possesses *antero-superior* and *postero-inferior surfaces* ; *lesser curvature*, forming right and upper concave border ; *greater curvature*, forming left and lower convex border.

Consists of (1) **cardia**, the region where œsophagus enters it ; (2) **fundus**, the enlarged upper end, above level of œsophageal entrance ; (3) **body** ; (4) **pyloric antrum**, a secondary dilatation separated by (5) **pyloric canal** from (6) **pylorus**, which joins duodenum. Junction is marked by *pyloric constriction* and muscle of stomach is thickened there (*pyloric sphincter*) and bulges in the mucous membrane to form *pyloric valve*. **Pyloric canal** is 1 in. long and nearly cylindrical, and enlarges very little, even when stomach is full.

œsophageal orifice lies about 4 in. behind 7th left costal cartilage, 1 in. from median plane. Fundus rises to level of 5th rib in mid-clavicular line ; and is separated by diaphragm from pericardium and heart. Pylorus lies against neck of pancreas, opposite 1st L. vertebra, $\frac{1}{2}$ in. to the right of median plane, about a hand's-breadth below xiphisternal junction, *i.e.* in *transpyloric plane* ; easily recognised owing to thickening of its muscular coat ; and a vein crosses its ant. surface, beneath peritoneum, at its junction with duodenum.

Peritoneal Connections.—Peritoneum covers its two surfaces, and the two layers meet at curvatures and proceed as so-called “folds” to be connected with other organs. Fold leaving lesser curvature proceeds, as **lesser omentum**, to liver. Fold leaving greater curvature is divided into 3 parts, which, however, are continuous with each other. (1) From upper part of fundus, near œsophagus, to diaphragm—**gastro-phrenic ligament**; (2) from left side of fundus to hilum of spleen—**gastro-splenic ligament** (gastro-splenic omentum); (3) from horizontal part of greater curvature—the **greater omentum**, the two layers of which extend as far as pelvis, double back on themselves and are attached to transverse colon.

Peritoneum on antero-sup. surface of stomach is continued on to ant. surface of duodenum; that on postero-inf. surface extends on to first $\frac{1}{2}$ -1 inch of first piece of duodenum, and is then reflected on to anterior surface of pancreas. Peritoneum leaves uncovered a small “bare area” on post.-inf. surface, just below œsophageal orifice: there the stomach is in direct contact with crus of diaphragm, and sometimes with left suprarenal gland.

Relations.—*Antero-superior surface* is related to liver to the right, diaphragm to the left, and ant. abdominal wall between these.

Postero-inferior surface is related, from above downwards, to (1) left crus of diaphragm, (2) left suprarenal and small part of left kidney, (3) splenic artery, (4) pancreas, (5) transverse mesocolon and sometimes transverse colon; it is separated from these by cavity of omental bursa (small sac of peritoneum). To the left and above, the postero-inferior surface is related to gastric surface of spleen, but is separated from it by omental bursa, gastro-splenic lig. (omentum) and great sac of peritoneum.

Right and left gastric vessels (pyloric and coronary) run along lesser curvature, between layers of lesser omentum; right and left gastro-epiploic vessels run between layers of greater omentum, near greater curvature.

When stomach is empty and intestines are distended, the transverse colon may be rolled up so as to lie anterior to stomach.

Incisura cardiaca is the notch between œsophagus and beginning of greater curvature. **Incisura angularis** is a notch on lesser curvature, opposite pyloric antrum. **Sulcus intermedius** is a notch on greater curvature, between pyloric canal and antrum.

Arteries of Stomach.—Left and right gastrics (coronary and pyloric) and gastro-epiploics, short gastric of splenic. **Lymphatics**: from part near cardia and lesser curvature end in para-cardial glands and glands lying along left gastric artery; from fundus and part below, in splenic and left supra-pancreatic glands; from pyloric end, in right supra-pancreatic and subpyloric glands and glands lying along left gastric artery and bile duct. **Nerves**: vagi; and branches from cœliac plexus, accompanying arteries.

Structure.—Serous peritoneal coat. Muscular coat : three layers. *Ext. longitudinal fibres* : continuous with those of œsophagus and duodenum. Best marked at lesser curvature ; thin and irregular elsewhere. *Middle circular fibres* : V-shaped loops, open towards fundus above ; complete circles near pylorus ; increased at pylorus to form sphincter. *Internal oblique fibres* : V-shaped loops passing from fundus, near œsophagus, towards pyloric end ; complete circles round fundus. Both middle and inner layers are continuous with circular fibres of œsophagus. **Mucous coat** : very thick : thrown into folds in empty stomach.

INTESTINUM TENUE (SMALL INTESTINE)

DUODENUM. JEJUNUM. ILEUM.

Duodenum differs from rest in having no mesentery, and by being directly attached to posterior wall, all except its first inch. About 10 in. long ; bent in form of letter C, enclosing head of pancreas.

Superior or 1st Part.—2 in. long ; very movable. Extends backwards, slightly to the right and upwards, from pylorus, opposite 1st l. vertebra, across portal vein and vena cava, to neck of gall-bladder. Lies in epigastrium. **Descending or 2nd Part.**—3 in. long ; descends anterior to renal vessels and medial margin of kidney, from epigastrium into umbilical region, to end at right side of 3rd lumbar vertebra. **Inferior or 3rd Part.**—About 5 in. long ; runs to the left almost transversely, in front of vena cava, to the aorta ; then ascends obliquely into epigastrium to left side of 2nd l. vertebra, where it turns abruptly forwards to join jejunum, forming duodeno-jejunal flexure.

Relations.—**Superior Part.**—*Peritoneum* covers anterior surface, and first $\frac{1}{2}$ -1 inch of posterior surface. Greater omentum is connected with first $\frac{1}{2}$ -1 inch of lower border, and lesser omentum with still more—sometimes nearly the whole—of upper border.

Anterior : quadrate lobe of liver. *Inferior* : head of pancreas. *Posterior* : v. portæ, gastro duodenal artery, bile duct ; and v. cava inferior, behind these three. Omental bursa (lesser sac) is posterior to its first $\frac{1}{2}$ -1 inch, separating it from pancreas. *Superior* : foramen epiploicum (Winslow), separating it from caudate process of liver ; hepatic artery, portal vein, bile duct proceeding to and from lesser omentum, between duodenum and foramen epiploicum.

Descending Part.—*Peritoneum* covers ant. and right lateral surface, except where transverse colon covers it. *Anterior* : gall-bladder above ; trans.colon in middle, overhung by liver ; coils of jejunum, and

sometimes right colic artery, below. *Right side*: right colic flexure and liver. *Left side*: head of pancreas. Bile duct and pancreatic duct pierce descending part of duodenum on postero-medial aspect, about its middle. *Posterior*: right renal vessels, pelvis of ureter, psoas, kidney near hilum.

Inferior Part.—*Peritoneum* covers ant. surface, except where mesenteric vessels cross. *Anterior*: sup. mesenteric vessels and root of mesentery at junction of transverse and ascending portions; coils of jejunum on both sides of that; transverse colon and mesocolon more anteriorly. *Superior*: head of pancreas. *Inferior*: coils of jejunum. *Posterior*: right psoas, ureter, spermatic vess., inf. v. cava, aorta—behind transverse part; left renal and spermatic vess., sympathetic trunk and psoas—behind ascending part.

Duodeno-jejunal flexure lies just below transpyloric plane, 1 in. to left of median plane, on left psoas and inf. mesenteric vein and left renal vessels; to the left of aorta; medial to kidney and ureter; below body of pancreas; posterior to transverse colon; below and posterior to transverse mesocolon, which encloses branches of middle colic vessels and separates the flexure from omental bursa (lesser sac) and stomach.

Peritoneum between post. abd. wall and left side of ascending piece of 3rd part of duodenum may be pinched up to form two folds, under cover of which are **sup. and inf. duodenal fossæ**. To left side of these the inf. mesenteric vein may raise another fold, bounding **para-duodenal fossa**.

Arteries to duodenum. Superior and inferior pancreatico-duodenal. **Lymphatics** end in subpyloric and sup. mesenteric glands and glands around bile duct. **Nerves**, from celiac plexus, accompany arteries.

Jejunum begins at duodeno-jejunal flexure, at left side of 2nd L. vertebra; is about 8 feet long, and is succeeded, without any hard-and-fast line of demarcation, by **ileum**, which is 12 feet long, and ends by joining large intestine at upper end of cæcum, in right iliac fossa, opposite point of intersection of intertubercular and right lateral planes.

Jejunum and ileum form coils found in all parts of abdomen below liver and stomach, and in pelvis—jejunum mostly to the left and above, ileum mostly to the right and below. Greater omentum and transverse colon and mesocolon hang down anterior to them. **Terminal part** of ileum ascends from pelvis and crosses ext. iliac art. to join large intestine. Coils are freely movable, because they are connected to post. wall of abdomen by wide fold of peritoneum, called **the mesentery** (p. 466).

Diverticulum Ilei (Meckel).—A blind diverticulum, at right angles to ileum; about 2 in. long; of same diameter as ileum; present in about 2 per cent of cases; found about 3 feet from lower end of ileum. End is usually free, but may be adherent to ant. abdominal wall at umbilicus. Due to persistence of proximal end of vitello-intestinal duct.

Arteries to jejunum and ileum, from the superior mesenteric.

Lymphatics end in mesenteric glands, except those from lower end of ileum which end in ileo-colic glands. **Nerves**, from celiac plexus, accompany arteries; include branches from right vagus.

Structure of Small Intestine.—*Serous coat* complete in jejunum and ileum, incomplete in duodenum. *Muscular coat*: outer longitudinal layer, inner circular. *Mucous membrane*: thrown into permanent crescentic, circular and spiral folds, called **plicæ circulares** (valvulae conniventes). They begin 1 inch from pylorus. Are large and closely set in lower part of duodenum and upper part of jejunum. Diminish in size and number till practically absent in lower part of ileum; hence wall of ileum is thinner. They are thickly covered with minute projections, called **villi intestinales**, which give them a velvety appearance. Villi are found from end to end of small intestine.

Nodules of lymphoid tissue (solitary glands) are scattered through small intestine (and large intestine as well). Aggregations of these are called **tonsillæ intestinales** (Peyer's patches); found opposite line of mesenteric attachment. $\frac{1}{2}$ to 3 in. long, $\frac{1}{4}$ to $\frac{1}{2}$ in. broad. Seen best in young subject; atrophy after middle age. Largest and most numerous in lower part of ileum.

Differences between the Jejunum and the Ileum.—Jejunum is distinguished from ileum by the following differences: (A) **While in abdomen and unopened**:—(1) it occupies upper and left part of intestinal area; (2) *walls*, thicker, more vascular and therefore redder; (3) *lumen*, wider and more liable to be empty—hence the name jejunum; (4) fat in mesentery is not so abundant near intestine at its upper part as it is lower down, and vessels close to the gut are more readily seen, with semi-translucent intervals ("windows") between them. (B) **When opened**:—(5) *plicæ circulares* (valvulae conniventes), larger and more closely set (and *villi* are larger); (6) *intestinal tonsils* (Peyer's patches), absent.

INTESTINUM CRASSUM

Large intestine begins in right iliac fossa as a blind head, called **intestinum cæcum**, with which **vermiform process** is con-

nected. Cæcum is succeeded by **colon** at level of intertubercular plane; ileum opens into large intestine at their junction, and the opening is guarded by **colic valve**. Colon is divided into: (1) **ascending colon**, which proceeds upwards on right side of post. wall of abdomen to inferior surface of liver, where it makes a bend, called **right colic flexure**, on anterior surface of kidney, and becomes (2) **transverse colon**, which arches across abdomen to lower end of spleen, on anterior surface or lateral border of left kidney, makes a sharp bend, called **left colic flexure**, and becomes (3) **descending colon**, which runs down left side of post. wall of abdomen to become continuous, at crest of ilium, with (4) **iliac colon**, which passes downwards and then medially, in left iliac fossa, to end, at medial margin of psoas major, by becoming (5) **pelvic colon**, which hangs down as a loop into pelvis, and ends, at middle of middle piece of sacrum, by becoming continuous with **intestinum rectum**.

Cæcum.—About $2\frac{1}{2}$ in. long and 3 in. broad. Lies in right iliac region, above lateral half of inguinal lig. (Poupart), entirely surrounded by peritoneum, but has no mesentery. Anterior abdominal wall is *anterior*, and is sometimes separated by greater omentum and coils of ileum. Ilio-psoas muscle, lateral cutaneous, femoral and genito-femoral nerves, and int. spermatic vessels are *posterior*. Ileum is *medial*. Relation to vermiform process is variable.

Vermiform Process (Appendix).—About $3\frac{1}{2}$ in. long, $\frac{1}{4}$ in. thick. Springs from postero-medial aspect of cæcum, 1 or $1\frac{1}{2}$ in. below ileo-cæcal orifice. May hang down into pelvis, or be directed upwards behind cæcum, or upwards and to left; in female it touches ovary when it lies in pelvis. Surrounded by peritoneum and has a small mesentery, attached to left side of mesentery of ileum, by which its artery reaches it. Vermiform process is most easily found by tracing downwards the anterior tænia coli of ascending colon.

Valvula Coli (Colic Valve, Ileo-cæcal Valve).—Lies opposite intersection of intertubercular and right lateral planes. Ileum enters medial aspect of junction of cæcum and colon, and telescopes walls of large intestine so as to produce a valve with two lips, superior and inferior. Opening is slit-like, long axis antero-posterior. Lips meet at ends of slit and are prolonged on to ant. and post. walls of gut by raised-up folds of mucous membrane, called *frenula valvulæ coli*.

Ascending Colon.—Continuous with cæcum at intertubercular plane; about 6 in. long. Extends through lumbar region into right hypochondrium, where it curves round lateral border of kidney and ends below liver, on ant. surface of kidney, by bending at right angles

(right colic flexure) to join transverse colon. Peritoneum covers its anterior surface and sides only.

Relations.—*Anterior*: ant. abd. wall; sometimes greater omentum and small intestine. *Lateral*: abd. wall. *Medial*: small intestine; psoas, kidney. *Posterior*: iliacus, ilio-lumbar lig., quadratus lumborum, transversus abd., diaphragm at tip of last rib; lateral cutaneous, ilio-inguinal, ilio-hypogastric, last thoracic nerves; subcostal vess., and 4th lumbar art. when it is anterior to quadratus; right kidney.

Right Colic Flexure (Hepatic Flexure).—Lies in right hypochondrium. Covered with peritoneum, except posteriorly. Liver is above and lateral and anterior; kidney is posterior; duodenum is medial.

Transverse Colon.—Nearly 20 in. long. Begins in right hypochondrium, at right colic flexure. Arches downwards and forwards, then upwards and backwards, lying both in epigastrium and in umbilical region. Ends in left hypochondrium, below spleen, anterior or lateral to kidney, opposite 11th rib, by making a sharp bend (left colic flexure) and becoming continuous with descending colon.

Relations.—First few inches, nearly transverse; covered with peritoneum, except posteriorly; lies in contact with descending duodenum and head of pancreas, behind liver and gall-bladder.

Remainder is free, and enclosed in peritoneum, which is continuous, below, with ascending or posterior layers of greater omentum, and above, with transverse mesocolon, which suspends it. *Anterior surface* is related to cavity of omental bursa (lesser sac), descending layers of greater omentum, ant. abdominal wall and diaphragm. *Posterior surface*, to 3rd part of duodenum, upper end of mesentery of small intestine, duodeno-jejunal flexure, coils of small intestine. *Upper border* is related to greater curvature of stomach anteriorly and its own mesocolon posteriorly. Tail of pancreas and spleen are above its termination.

Left Colic Flexure (Splenic Flexure).—Lies in left hypochondrium, below spleen and tail of pancreas, anterior and lateral to kidney. Lower and anterior part of diaphragm is in front. It is at a higher and deeper level than right colic flexure. Peritoneum covers it, except posteriorly, and it is attached to diaphragm by phrenico-colic ligament, opposite 11th rib.

Descending Colon.—About 4 in. long. Much narrower than ascending. Begins in left hypochondrium. Curves downwards and medially along lateral border of kidney; enters lumbar region and descends vertically to crest of ilium, becoming continuous there with iliac colon.

Relations.—Covered with peritoneum on ant. aspect and sides, to greater extent than ascending, except when distended. *Anterior*: coils of small intestine. *Medial*: kidney above, psoas below. *Lateral*: diaphragm, transversus abdominis. *Posterior*: diaphragm, quadratus, transversus abd.; last thoracic, ilio-hypogastric, ilio-inguinal nerves; subcostal vessels, and sometimes 4th lumbar artery.

Iliac Colon.—5 or more in. long. Begins in lumbar region, at posterior part of crest of ilium ; descends into iliac region. At level of ant. sup. iliac spine it turns medially, above inguinal lig., and ends at medial border of psoas by becoming pelvic colon. It may be close to inguinal lig. or up to 1 inch above it.

Relations.—Covered with peritoneum, except posteriorly. *Anterior*: coils of small intestine. *Posterior*: iliacus, psoas ; lateral cutaneous, femoral, genito-femoral nerves ; spermatic vessels, ext. iliac artery.

Pelvic Colon.—May be nearly as long as transverse colon ; usually much shorter ; occasionally longer. Begins at medial border of left psoas ; forms a loop, lying in pelvis ; ends opposite middle piece of sacrum by becoming rectum. Occasionally very short and takes a straight course. Surrounded by peritoneum and suspended by pelvic mesocolon. Coils of small intestine lie above. It lies on bladder, or uterus and bladder. Superior hæmorrhoidal artery is posterior to its lower part. Peritoneum separates it *posteriorly* from hypogastric (int. iliac) vessels, upper part of sacral plexus, piriformis and sacro-iliac joint ; *laterally* from ext. iliac vessels, forwardly directed branches of hypogastric vessels, obturator nerve, ureter, and ductus deferens or ovary—all of left side.

Structure of Large Intestine.—Serosus peritoneal coat : complete over cæcum, vermiform process, transverse and pelvic cola ; incomplete over others. The peritoncum presents little pouches filled with fat, called **appendices epiploicæ**, all over large intestine except cæcum and rectum.

Muscular coat: *Outer longitudinal fibres* are in form of 3 equidistant bands, called **tæniæ coli**, between which the longitudinal stratum is absent or exceedingly thin. At one end the tæniæ converge upon base of vermiform ; at the other they spread out to become continuous with longitudinal layer of rectum. They are $\frac{1}{3}$ th shorter than potential length of colon, which is therefore puckered up into 3 rows of sacculations, called *haustra coli*. *Inner circular fibres* form continuous layer. **Mucous coat**: smooth ; plicæ circulares (valvulæ conniventes) absent, but folds, effaceable by stretching, are numerous. Lymph nodules are scattered through it, and are especially numerous in vermiform process.

Differences between Large and Small Intestines and between the several Parts of Colon.—*Large intestine* is distinguished from *small* by **appendices epiploicæ**, tæniæ coli, sacculations, larger calibre, absence of plicæ circulares (valvulæ conniventes) and of villi. *Ascending colon* has larger calibre than *descending* and *iliac cola*. *Transverse* and *pelvic cola* differ from others in having complete peri-

toneal covering, and transverse differs from pelvic in having not one but two lines of peritoneal attachment—greater omentum and transverse mesocolon.

Cæcal Folds and Fossæ.—**Processus retrocæcalis**: a fossa extending upwards behind cæcum and lower end of colon. When recess is present, vermiform process often lies in it. **Plica ileocæcalis**: a fold with free edge to left, attached to ileum above, cæcum to right, vermiform or its mesentery below. **Recessus ileocæcalis inferior**: a fossa between this fold and mesentery of vermiform. **Recessus ileocæcalis superior** lies behind ileo-colic fold, which stretches across front of upper part of ileo-cæcal junction.

Recessus intersigmoideus: a fossa under cover of pelvic mesocolon, on left side of 5th L. vertebra.

Arteries of Colon, etc.—To *cæcum* and *vermiform process*, from sup. mesenteric and ileo-colic; *asc. colon*, ileo-colic and right colic; *transverse colon* and *flexures*, right, middle and left colic; *desc. colon*, left colic; *iliac colon*, left colic and sigmoid branches of inf. mesenteric; to *pelvic colon*, from sigmoid and sup. hæmorrhoidal. **Lymphatics**: from *cæcum*, and *vermiform* to lower ileo-colic lymph glands; *asc. colon*, ileo-colic and right colic; *transverse colon* and *flexures*, mesocolic. From ileo-colic, right colic and mesocolic glands, which are associated with arteries of same name, efferents go to mesenteric glands. From *desc.*, *iliac* and *pelvic colons* to inf. mesenteric glands and thence to pre-aortic. **Nerves**: from plexuses accompanying arteries.

Intestinum Rectum.—5 in. long. Begins at middle piece of sacrum. Follows curve of sacrum and coccyx, lying posterior to bladder, seminal vesicles and ducts, and prostate *in male*; posterior to uterus and vagina *in female*. Ends 1 inch beyond tip of coccyx (on level with apex of prostate in male), by bending backwards to become anal canal. Lower part is dilated—*ampulla recti*.

Peritoneum covers anterior surface and sides of *upper third*, forming *para-rectal fossa* on each side; covers ant. surface of *middle third*, and is reflected on to bladder (or vagina), forming bottom of recto-vesical (or recto-vaginal) pouch, 3 in. from anus (and about 1 in. above base of prostate, in male). *Lowest third* is devoid of peritoneum and is imbedded in pelvic fascia.

Anal Canal.—1½ in. long. Directed dorsally and downwards from end of rectum, through pelvic floor, to open on exterior as *anus*. Circular fibres thickened to form *sphincter ani internus*. Surrounded by sphincter externus and levatores ani, which keep its lateral walls in apposition.

Relations of Rectum.—*Anterior, in male*: pelvic colon or small intestine; seminal vesicles, ductus deferentes, bladder; prostate. *Anterior, in female*: vagina below; pelvic colon or small intestine separate it from uterus and upper part of vagina. *At sides*: pelvic colon or ileum, separated by peritoneum, above; coccygeus, levator ani and sup. and middle hæmorrhoidal vessels, below. Ureter is lateral, some distance away. *Posterior*: lower part of sacrum, coccyx, ano-coccygeal body, at median plane; lower part of piriformis, coccygeus, levator ani, on each side. Between it and this bed are: middle sacral vessels, sympathetic trunks, lower lateral sacral vessels, 3rd, 4th and 5th sacral, and coccygeal nerves, besides connective tissue. Sup. hæmorrhoidal art., at first posterior, divides to pass down along its sides, and to sink into its substance, about its middle.

A muscular band (recto-urethral muscle), on each side of median plane, extends forwards from ant. surface of rectum at lower end of ampulla, to be attached to apex of prostate, fasciæ of urogenital diaphragm and the urethra as it emerges from prostate.

Relations of Anal Canal.—*Posterior*: ano-coccygeal body. *Lateral*: levator ani, external sphincter ani, ischio-rectal fossa. *Anterior, in male*: sup. and inf. fasciæ of urogenital diaphragm (triangular ligament) and structures between them; “central point” of perineum, bulb of urethra. *Anterior, in female*: separated from vagina by “perineal body.”

Curvatures of Rectum.—Antero-posterior flexure. Three lateral flexures above ampulla, two concave to left and one to right, each having corresponding fold in interior, called *plicæ transversales recti*, including mucous, submucous and part of muscular coat.

Distal half of anal canal is called *pars analis recti*. Mucous membrane of upper half of anal canal is thrown into longitudinal *columnæ rectales*, separated by grooves. At lower end of each groove a crescentic fold, called *anal valve*, projects up and bounds a little pocket—*sinus rectalis*.

Arteries to rectum and anal canal, from sup., middle and inf. hæmorrhoidal and middle sacral. **Veins** are drained partly into *portal system*, through sup. hæmorrhoidal, and partly into *systemic veins* through middle and inf. hæmorrhoidal and middle sacral. **Lymphatics** from rectum and upper part of anal canal pass through ano-rectal and inferior mesenteric and hypogastric glands to lumbar glands; from lower part of anal canal and anus to superficial subinguinal glands. **Nerves**: from aortic plexus with sup. hæmorrhoidal artery; from hypogastric plexus; from 2nd, 3rd, 4th sacral nerves directly, and from 3rd and 4th through inf. hæmorrhoidal nerve.

HEPAR

Liver.—Largest gland in body. About 50 ounces in weight. Lies in upper right quadrant of abdomen, in right hypochondrium and in epigastrium. Descends slightly into right lumbar. May reach into left hypochondrium.

Lobes.—Liver is divided into **right** and **left lobes** by attachment of falciform lig. on ant. and sup. surfaces, by fossa for lig. teres on inf. surface, by fossa for ductus venosus on post. surface. Right lobe forms great bulk of liver; on its inferior surface there is a circumscribed area called *lobus quadratus*; another, on posterior surface, is called *lobus caudatus* (Spigelian lobe).

Surfaces.—Right lateral, superior, anterior, inferior or visceral, posterior.

Right lateral surface.—Quadrilateral and convex, lies against diaphragm, opposite 7th to 11th ribs, in mid-axillary line, and against transversus abdominis for $\frac{1}{2}$ in. below ribs.

Superior surface: quadrilateral, fits dome of diaphragm, which separates it from pleura, lungs, pericardium and heart. Area opposite heart is concave. Areas opposite lungs convex, especially on right side. Reaches level of 4th intercostal space on right side: $\frac{1}{2}$ in. lower on left; and level of xiphisternal junction in median plane. **Anterior surface:** triangular, slightly convex. Related to anterior abdominal wall (sheaths of recti) in subcostal angle, and to diaphragm on each side. Falciform lig. is attached to ant. and sup. surfaces, 1 to 2 in. to the right of median plane.

Visceral surface.—Quadrilateral; directed downwards, backwards, and to the left. Irregular in contour. **Fossa venæ umbilicalis** (fissure for lig. teres), a deep cleft which lodges lig. teres, divides it into areas belonging to right and left lobes. On left lobe *tuber omentale*, a convex area which fits against lesser omentum, lies to left of upper end of fossa; and the rest of the surface, forming the concave *gastric impression*, lies upon stomach. On right lobe, immediately to right of fossa v. umbilicalis, is **lobus quadratus**, quadrilateral and slightly concave; *bounded on left* by fossa v. umbilicalis, *on right* by broad, shallow **fossa for gall-bladder**, *below* by inferior sharp margin of liver, *above* by porta hepatis. Lobus quadratus lies anterior to pylorus and 1st part of duodenum, which may produce impressions on it; and below these it is anterior to the first part of transverse colon. To the

right of gall-bladder, above inferior border of liver, is *colic impression*, for right colic flexure. Above and posterior to that is *renal impression*. To left side of lower part of renal impression is *duodenal impression* for upper end of 2nd part of duodenum. **Porta hepatis** (portal fissure) is a deep, wide cleft connecting upper ends of fossæ for umbilical vein and gall-bladder. *Bounded above* by processus caudatus, *below* by quadrate lobe. Lesser omentum is attached to its margins. It *transmits* hepatic duct, branches of hepatic art. and of vena portæ, in that order from before backwards; and lymphatics and nerves as well.

Posterior surface is triangular; irregular in contour, and concave from right to left, owing to the forward projection of bodies of vertebræ. Areas belonging to right and left lobes are separated by **fossa ductus venosi**, a deep fissure, continuous with left end of porta hepatis. It lodges fibrous remains of ductus venosus, and lesser omentum is attached to its bottom. To left of fossa are the attachment of left triangular lig., and the *œsophageal impression*, produced by anterior lip of hiatus œsophageus of diaphragm. To right of fossa is **lobus caudatus** (Spigelian lobe), which is *bounded on left* by fossa ductus venosi, *on right* by fossa venæ cavæ, inferiorly by porta hepatis, superiorly by left hepatic vein and lig. venosum bending to the right to join v. cava. It lies in relation to crus of diaphragm, which intervenes between it and thoracic aorta, opposite 10th, 11th and 12th TH. vertebræ. Between it and crus of diaphragm is superior recess of omental bursa (small sac of peritoneum). Lower end of caudate lobe projects into omental bursa, behind lesser omentum. Nipple-like prominence sometimes present on left part of lower end is called *processus papillaris*, and notch limiting it is produced by contact with celiac art. Ridge running to right, between v. cava and porta hepatis, is called **processus caudatus**, and forms upper boundary of foramen epiploicum (Winslow). **Fossa venæ cavæ** is a broad deep groove on right of caudate lobe, and may be in form of tunnel. To right of v. cava is a large convex area devoid of peritoneum, in direct contact with diaphragm, and called the "bare area." On this area, close to vena cava, is the *supra-renal impression*, which may extend on to inferior (or visceral) surface also. Coronary and right triangular lig. are attached to margins of bare area.

Inferior surface of liver is separated from right lateral,

anterior and superior surfaces by distinct margins. Otherwise the surfaces are continuous over obtuse, rounded borders.

Liver may be roughly marked out on surface *anteriorly* by (1) a line drawn from a point 1 in. below and medial to left nipple, to a point $\frac{1}{2}$ in. below right nipple, dipping to cross median plane at xiphisternal junction; (2) a line, convex to the right, from $\frac{1}{2}$ in. below right nipple to $\frac{1}{2}$ in. below lower margin of ribs; (3) from there a line drawn to cut transpyloric plane in median plane, and then up to starting-point near left nipple. *Posteriorly* by an oblique line drawn along 12th right rib and continued till it strikes 9th left. From there a line dipping to median plane and rising again to 8th right rib, just below inferior angle of scapula. From there a curved line, convex to right, to lower margin of thorax.

Blood-vessels. Hepatic art. and portal vein convey blood to liver, and hepatic veins remove it. **Nerves** Branches from left vagus pass to it, from antero-superior surface of stomach, between layers of lesser omentum. Branches from coeliac plexus accompany hepatic artery. **Lymphatics** end in hepatic, coeliac, para-cardial glands, and glands lying on left gastric artery, and ant. and post. mediastinal glands.

Vesica Fellea (Gall-Bladder).—Pear-shaped. Lies on visceral surface of liver. Large inferior end or **fundus** projects beyond liver and lies against ant. abdominal wall, opposite angle between lateral edge of right rectus abdominis and lower margin of thorax, and is covered with peritoneum. Ant. surface of gall-bladder is adherent to liver; post. surface is clothed with peritoneum and lies against beginning of transverse colon below, and 2nd part of duodenum above. Upper end or **neck** narrows and forms **cystic duct**, which runs posteriorly and medially for over an inch, and joins hepatic duct to form bile duct.

Ductus Hepaticus.—About 1 in. long; is formed in the porta hepatis by union of right and left hepatic ducts from right and left lobes of liver.

Ductus Choledochus (Bile Duct).—3 to 4 in. long; begins, either just inside or outside porta hepatis, by union of cystic and hepatic ducts. Descends between layers of lesser omentum, at its right free margin, in front of vena portae, to the right of hepatic art. Next, behind 1st part of duodenum, in front of portal vein, to right of gastro-duodenal artery; lastly, in front of inf. v. cava or right renal vein, on right side of main pancreatico-duodenal vein, in a groove on

post. surface of head of pancreas, where it meets pancreatic duct. Bile and pancreatic ducts pass obliquely through postero-medial wall of duodenum about its middle ; and both end in a dilated trunk, called *ampulla of Vater*, which opens on an eminence in duodenum, called *papilla duodeni*, over which one of the plicæ circulares forms a "hood." (*Plica longitudinalis duodeni* is a ridge of mucous membrane which descends from papilla and is a guide to it.)

PANCREAS

Pancreas.—An elongated gland, lying obliquely across upper part of post. abdominal wall, in epigastrium and slightly in left hypochondrium. Subdivided into head, neck, body and tail, named in that order from right side towards left and upwards.

Head lies in loop of duodenum. *Post. surface* rests against inf. v. cava, right renal vessels, left renal vein, and slightly on aorta. *Ant. surface* : covered with peritoneum of omental bursa above ; in direct contact with transverse colon at a lower level, and separated by peritoneum from jejunum, below level of colon. Lower part of head (*processus uncinatus*) curves to left, behind sup. mesenteric vessels, and upwards behind neck, from which v. portæ separates it. Bile duct descends between pancreas and inf. v. cava. Pancreatico-duodenal vess. present varying relations to pancreas.

Neck, about 1 in. long, arises from ant. aspect of upper part of head and passes to left and forwards and upwards. *Posterior* to it are portal vein and processus uncinatus, opposite 1st L. vertebra. *Anteriorly* it is separated from pyloro-duodenal junction by peritoneum of omental bursa (lesser sac). Gastro-duodenal art. and its pancreatico-duodenal branch descend at junction of head and neck.

Body extends to left and upwards to spleen. *Anterior surface* : covered with peritoneum of omental bursa (lesser sac), and stomach rests on it ; a prominence on the upper part of body, near neck, is called *tuber omentale*, and abuts against lesser omentum, which separates it from liver. *Inferior surface* : covered with peritoneum ; rests upon duodeno-jejunal flexure, coils of jejunum, left end of transverse colon. *Posterior surface* is in relation with aorta and origin of sup. mesenteric art. ; splenic vein, left renal and suprarenal vessels, terminations of inf. mesenteric and left spermatic

veins; cœliac (solar) plexus and ganglion; suprarenal gland, pelvis of ureter and kidney; and, on a more posterior plane, with left crus of diaphragm, sympathetic trunk and psoas.

Cœliac art. projects forwards above *upper border*; splenic art. runs tortuously along it, or dorsal to it. Transverse mesocolon is attached to *lower border* of anterior surface.

Tail, the pointed left end of pancreas, between the layers of lienorenal lig., abuts against a depression on lower and medial part of gastric surface of spleen, above left (splenic) flexure of colon.

Ductus Pancreaticus. — Lies in substance of gland near posterior surface. Begins at tail; runs along body to neck; bends down in substance of head, pierces 2nd part of duodenum, in company with bile duct.

Ductus p. accessorius. — Arises in lower part of head, crosses ventral to main duct, gives it a communicating branch; enters duodenum, $\frac{3}{4}$ inch above and ventral to main duct.

Arteries. — Superior and inferior pancreaticoduodenal, pancreatic branches of splenic, a few from hepatic. **Lymphatics** end in subpyloric, supra-pancreatic, cœliac, splenic and sup. mesenteric glands. **Nerves**: from cœliac plexus, accompany arteries.

PERITONÆUM

Peritoneum is the large continuous sheet of serous membrane which lines the abdominal walls, except where viscera are in direct contact, and is reflected on to the viscera. It passes directly on to some viscera, holding them against the posterior abdominal wall. Other viscera are connected by "folds" to the parietes and to one another. Where a fold is "attached" to parietes or to an organ the two layers which compose it separate from one another.

Three different kinds of names are given to folds, more or less arbitrarily: omenta; mesenteries; ligaments.

Omentum Minus (Lesser Omentum). Attached to lesser curvature of stomach lig. hepato-gastricum and to first inch, or more, of 1st part of duodenum (lig. hepato-duodenale); to margins of porta hepatis and bottom of fossa for ductus venosus; to diaphragm for $\frac{1}{2}$ inch, between fossa for d. venosus and cardia of stomach. The two layers are continuous with one another at its right free border, which forms anterior boundary of foramen epiploicum; and they separate at lesser curvature to enclose stomach; meet again

at greater curvature to form gastro-phrenic lig., gastro-splenic lig. (gastro-splenic omentum) and greater omentum.

Relations. — **Between the layers**, at *right free border*, are the hepatic art. (to the left), bile duct (to the right), vena portæ (behind and between); the right and left gastric arteries with their veins, *near stomach*; cystic and hepatic ducts, *near liver*; besides nerves, lymph vessels and glands.

Anterior surface is in relation to tuber omentale of liver.

Posterior surface forms part of ant. wall of omental bursa (lesser sac); lower end of caudate (Spigelian) lobe projects downwards behind it; and it is separated also by the cavity and post. wall of bursa from tuber omentale of pancreas, v. cava inferior, crura of diaphragm, right inferior phrenic art., coeliac art. and plexus.

Omentum Majus (Greater Omentum) hangs down from stomach like an apron. Consists of 4 layers. Two anterior layers descend from greater curvature of stomach as far as pelvis, turn back and run upwards, as two posterior layers, to transverse colon; separate to enclose it; meet again and proceed to lower border of pancreas, as transverse mesocolon. At pancreas, the two layers separate finally, the one passing upwards over structures on post. abd. wall, the other downwards.

Lower part of cavity of omental bursa is enclosed between ant. and post. layers, and these layers are continuous with one another at right and left borders of omentum, as well as at lower border. Left border, traced upwards, becomes continuous with gastro-splenic and lienorenal ligaments.

Ant. surface is in relation to ant. abdominal wall. Transverse colon is hidden by the two anterior layers immediately below stomach; and all four layers are anterior to small intestine.

Right and left gastro-epiploic vessels, lymph glands and vessels lie between the two ant. layers near stomach. Near right and left borders there are anastomoses between branches of gastro-epiploic and colic arteries.

The two ant. layers are occasionally adherent to transverse colon, and below that level the cavity of omental bursa may be obliterated; the name *gastro-colic lig.* is sometimes given to the part of omentum between stomach and colon, when this adhesion is present.

Mesenterium (Mesentery Proper).—A wide, broad fold, attaching jejunum and ileum to post. wall of abdomen. Its posterior border or root, about 6 in. long, is attached to post.

wall from left side of 2nd L. vertebra to right iliac fossa, above sacro-iliac joint. Its greatest width from intestine to parietes is about 8 in.

Its root crosses 3rd part of duodenum, aorta, inf. v. cava; right ureter, genito-femoral n., int. spermatic vessels and psoas. Between its layers are sup. mesenteric vessels and their intestinal branches; nerves, lymph vessels (lacteals) and glands; and jejunum and ileum at free border. Fat between layers at upper part of mesentery is less abundant near intestine than it is lower down; vessels can more easily be seen through it near the intestine, and intervals between vessels are more or less translucent.

Mesenteriolum Processus Vermiformis (Mesentery of Appendix).—A small triangular fold enclosing vermiform process in one border, its artery in another, and attached by third border to lower part of left lamina of mesentery proper.

Transverse Mesocolon.—A broad fold connecting transverse colon to post. abdominal wall, along lower border of body of pancreas, and sometimes across front of head. Forms part of posterior wall of omental bursa. *Anterior* surface is in relation to stomach; *posterior*, to small intestine. Between layers are middle colic vessels, branches of right and left colic; lymph glands and vessels; nerves.

Pelvic Mesocolon.—Attached along a N-shaped line extending from medial margin of psoas, along ext. iliac vessels, to medial side of left common iliac, and then turns sharply down to 3rd piece of sacrum. Between its layers are:—Pelvic colon; sigmoid vessels, which enter at oblique upper attachment; sup. hemorrhoidal vessels, which enter at vertical attachment; lymph vessels and glands; nerves.

Lig. Falciforme Hepatis.—Triangular sheet attached by *base* to sup. and ant. surfaces of liver, by *supero-anterior border* to diaphragm and ant. abdominal wall, down to umbilicus. Two layers are continuous round free *postero-inferior border*, which extends from umbilicus to inferior margin of liver.

Lig. Teres Hepatis.—Fibrous remnant of (left) umbilical vein of fetus; extends (enclosed in lig. falciforme at its free edge) from umbilicus to liver; thence in fossa of umbilical vein to join left branch of vena portæ.

Lig. Venosum.—Fibrous remnant of foetal ductus venosus, lies in fossa of d. venosus; extends from left branch of v. portæ to v. cava as it leaves liver.

Lig. Coronarium Hepatis.—Upper and lower layers of **coronary ligament** are names given to peritoneum as it is reflected from diaphragm on to liver, at upper and at lower margins of “bare area.” **Right triangular lig.** (right lateral) is name given to these layers where they become continuous, round a free edge, at right lateral angle of bare area. Left end of upper layer is continuous with right side of falciform ligament. Left end of lower layer is continuous with peritoneum covering vena cava, on post. wall of foramen epiploicum.

Left Triangular Lig. (Left Lateral).—*Postero-superior* border is attached to diaphragm, *antero-inferior* to left lobe of liver; *left* border is free.

Lig. Phrenico-colicum.—A triangular fold attached by one border to left (splenic) flexure of colon, by another to diaphragm opposite 11th rib, in mid-axillary line. Third is free and looks forwards. Spleen rests on upper surface.

Lig. Gastro-lienale (Gastro-splenic Lig. ; Gastro-splenic Omentum).—Two layers proceeding from greater curvature, at left border of stomach, to lips of hilum on gastric surface of spleen. Continuous with gastro-phrenic lig., above; with two ant. layers of greater omentum, below. Encloses left gastro-epiploic and short gastric branches of splenic art., accompanied by veins, lymph vessels, glands, and nerves. Forms part of left boundary of omental bursa (lesser sac). Anterior or right surface is in relation to stomach; posterior surface is in relation to gastric surface of spleen.

Left or posterior layer passes over spleen, adherent to its gastric, diaphragmatic and renal surfaces, and comes into relation again with right layer, and the two pass from spleen to left kidney as **lieno-renal ligament**, which helps to form left boundary of omental bursa. Between the layers of lieno-renal lig. are splenic vessels, with lymph vessels, lymph glands, nerves, and tail of pancreas. The layers separate at kidney and pass to right and left.

Lig. Gastro-phrenicum.—Two layers proceeding to diaphragm from uppermost part of greater curvature of stomach.

Lig. Hepato-colicum.—Present occasionally; attached superiorly to liver and gall-bladder, inferiorly to beginning of transverse colon, posteriorly to lesser omentum and duodenum; free border is directed to the right and anteriorly.

Right and left gastro-pancreatic folds of peritoneum are raised up by hepatic and left gastric arteries as they run to duodenum and œsophageal end of stomach, respectively, and turn round borders of omental bursa to enter between layers of lesser omentum.

Plicæ Epigastricæ; Plicæ Umbilicales Laterales; Plica Umbilicalis Media.—Folds of peritoneum raised up on ant. abdominal wall by inf. epigastric arteries, obliterated parts of umbilical arteries and urachus, respectively.

Processus vaginalis peritonæi is a diverticulum which precedes testis in its passage from abdomen to scrotum.

Plica vesicalis transversa is a transverse fold seen on upper surface of empty bladder.

Superior and lateral false ligaments of bladder are unnecessary names devised for peritoneum passing from bladder on to anterior abdominal wall and to side wall of pelvis.

Sacro-genital fold.—A small fold curving from bladder, along side wall of pelvis, towards rectum. When bladder is empty the folds of opposite sides meet and form a shelf projecting backwards from posterior border of bladder. Ductus deferentes and upper ends of seminal vesicles are found in it. **Plica recto-uterina**, the corresponding fold in female, is connected with cervix uteri, and may meet its fellow across back of cervix.

Excavatio Recto-vesicalis (Recto-vesical Pouch).—Pouch between rectum and bladder. Floor (3 inches from surface of perineum) is formed by peritoneum passing from rectum on to upper border of base of bladder. Its mouth is bounded by sacro-genital folds.

Excavatio Recto-uterina (Recto-vaginal Pouch of Douglas), between rectum behind, uterus and upper $\frac{1}{3}$ of vagina in front. Floor is formed by peritoneum passing off rectum on to post. wall of vagina. Mouth is bounded by plicæ recto-uterinæ.

Excavatio Vesico-uterina.—Formed by peritoneum passing off anterior surface of uterus on to upper surface of bladder.

Ligamentum latum uteri (Broad lig.) stretches from side of uterus to side wall of pelvis, a short distance in front of ureter and hypogastric art. Its two layers are continuous over free upper or anterior border, medial $\frac{2}{3}$ of which encloses uterine (Fallopian) tube; lateral $\frac{1}{3}$ extends on to ext. iliac vessels, is called **suspensory lig. of ovary**, and encloses ovarian vessels and nerves. Inferior or posterior border is attached to upper end of vagina and upper surface of levator ani. A secondary fold is raised up on ant. surface by contained lig. teres uteri. Another is raised up on post. surface by lig. ovarii; lateral to and continuous with this fold the broad lig. sends backwards two layers, called **mesovarium**, to become continuous with epithelial covering of ovary. **Meso-salpinx** is the portion of broad ligament between uterine tube and ovary. **Mesometrium** is the portion of broad lig. below level of mesovarium.

Ureter passes forwards below lower border of broad lig. Uterine art. runs medially to uterus above ureter, between the layers, at the attachment of lower border. Vaginal artery, as it approaches vagina, is beneath lower border and ureter.

Obliterated umbilical (hypogastric) artery, vesical art., and obturator vessels and nerve cross attachment of broad ligament to side wall of pelvis. Posterior surface is related to small intestine or pelvic colon; anterior surface is related to bladder, and (when bladder is empty) to side wall of pelvis also, or to a loop of intestine. Between the two layers are uterine tube, lig. teres, lig. ovarii, ovarian and uterine vessels and nerves; ep-oöphoron and par-oöphoron.

CAVUM PERITONÆI

Peritoneal Cavity.—Space enclosed by peritoneal membrane; only potential till abdomen is opened, or unless distended with fluid or gas. Communicates with lymph system by minute openings called *stomata*, scattered here and there, especially over diaphragm. In the male, the peritoneum is a closed sac, in respect that it does not communicate with the exterior. In female, the uterine tubes open into it, and it therefore communicates with exterior through uterine tubes, uterus and vagina.

Peritoneal cavity is subdivided into two: 1. **Great Sac of peritoneum**—the space opened into when ant. abdominal wall is cut through. Greater omentum, transverse colon and mesocolon divide it into an upper, anterior portion and a lower, posterior. These are continuous with each other round lower and lateral borders of greater omentum. Lower portion is further divided into two right and left parts by the mesentery proper.

II. **Omental Bursa** (Small sac of peritoneum) is a diverticulum from great sac. Its upper part is posterior to great sac; its lower part projects into great sac. Its *anterior wall* is formed by: (1) peritoneum covering caudate (Spigelian) lobe of liver; (2) post. layer of lesser omentum; (3) peritoneum on postero-inferior surface of stomach; (4) the second of the two anterior layers of greater omentum. *Posterior wall*: (1) anterior of the two posterior layers of greater omentum; (2) peritoneum on ant. surface of transverse colon; (3) anterior layer of transverse mesocolon; and (4) the continuation of that layer upwards over pancreas, upper

part of left kidney, left suprarenal gland, cœliac art. and its branches, cœliac plexus, and crura of diaphragm.

The part of omental bursa between caudate (Spigelian) lobe and right crus is a small recess bounded on right and above by reflection of peritoneum from crus on to caudate lobe, and on left side by posterior layer of lesser omentum passing from the fossa of the ductus venosus to diaphragm. *Upper boundary* of omental bursa, to the left of this recess, is formed by peritoneum reflected from diaphragm on to posterior surface of œsophageal end of stomach, and by inferior layer of gastro-phrenic ligament. *Upper part of left border or boundary* is formed by right or medial layers of gastro-splenic and lienorenal ligaments. *Lower part of left boundary*, the *lower boundary*, and *lower part of right boundary* are formed by continuity of 2nd and 3rd layers of greater omentum. *Upper part of right boundary* is formed by reflection from posterior surface of duodenum to anterior surface of pancreas. Above that the right boundary is deficient, the omental bursa communicating there with great sac, through epiploic foramen.

Foramen Epiploicum (Winslow). A short peritoneal canal, posterior to free right border of lesser omentum, uniting the cavities of omental bursa and great sac, opposite upper part of 1st l. vertebra. *Anterior* are: portal vein, hepatic artery and bile duct, in free border of lesser omentum. *Posterior*: v. cava inferior and right crus. *Superior*: caudate process of caudate (Spigelian) lobe of liver. *Inferior*: 1st part of duodenum; and portal vein, hepatic artery, bile duct, on their way to and from lesser omentum.

Splenic, left gastric, and hepatic arteries begin behind post. wall of omental bursa and end in front of ant. wall, between layers of omenta. Left gastric ends in front of bursa, having turned round its upper border, at œsophageal end of stomach. Hepatic comes to lie in front of for. epiploicum by turning round right border of bursa, at junction with inf. wall of for. epiploicum. Splenic art. runs behind bursa to kidney, passes into lienorenal lig., lying therefore on left boundary of bursa; sends its short gastric and gastro-epiploic branches over the part of left boundary formed by right layer of gastro-splenic ligament, to reach the stomach, which lies on anterior wall of bursa.

Continuity of Peritoneal Membrane as seen in Section or traced in Cadaver

Continuity of peritoneal membrane in great sac and in omental bursa may be traced in vertical and transverse directions.

Vertical Direction.—**Great sac:** Begin at anterior layer of lesser omentum. Follow that layer to lesser curvature; over antero-superior surface of stomach to greater curvature; as 1st layer of greater omentum to its lower border; upwards as 4th layer of omentum to transverse colon; over posterior surface of transverse colon, and then upwards and backwards to lower border of pancreas, as posterior layer of transverse mesocolon. From there downwards for a little, over post. wall, to root of mesentery; downwards and forwards as right lamina of mesentery, round intestine, and back to posterior wall as left lamina of mesentery. From there downwards over posterior wall to pelvis, over rectum on to bladder, in male, on to vagina and uterus and then to bladder, in female. From bladder on to anterior abdominal wall, over which it is traced uninterruptedly to lower surface of diaphragm. From diaphragm to liver, as upper layer of coronary ligament, if on right side of falciform ligament; or as upper layer of left triangular ligament, if on left side. Over upper and anterior surfaces of liver, round inferior free border of liver, and over lower surface to porta hepatis; and from there to starting-point on lesser omentum.

Omental Bursa.—Begin at posterior layer of lesser omentum. Follow, successively, that layer, peritoneum on postero-inferior surface of stomach, 2nd layer of greater omentum, 3rd layer, peritoneum on anterior surface of transverse colon, anterior layer of transverse mesocolon, peritoneum on pancreas, right crus. Reflected on to upper end of caudate (Spigelian) lobe, downwards over that lobe and on to starting-point on lesser omentum; or, alternatively, from a point more to the left, from diaphragm directly on to lesser omentum.

Transverse Directions—1. **At Level of 4th Lumbar Vertebra.**—**Great sac:** Begin at median plane on ant. abdominal wall. Follow peritoneum to left over ant. and lateral walls of abdomen; over sides and front of descending colon, onwards to root of mesentery; left layer of mesentery, round intestine, right layer; back to posterior wall. Then over posterior wall, over sides and front of ascending colon to lateral wall of abdomen, and then back to starting-point.

Omental Bursa.—Four layers of greater omentum; 1st and 4th, continuous at lateral borders; 2nd and 3rd, continuous at lateral borders, and enclose cavity of omental bursa.

2. **At Level of Pylorus.**—Trace to left and slightly upwards. **Great sac:** Begin at pylorus. Follow successively: peritoneum on antero-superior surface of stomach; left layer of gastro-splenic ligament; over gastric, diaphragmatic, renal surfaces of spleen; left layer of lieno-renal ligament; over kidney to left side of diaphragm, over diaphragm to falciform ligament; left layer of falciform ligament; round liver to falciform ligament again; right layer of falciform ligament; over right side of diaphragm to kidney; over kidney and first part of duodenum to pylorus.

Omental Bursa.—Begin at pylorus, pass over postero-inferior

surface of stomach, right layers of gastro-splenic and lieno-renal ligaments; to the right over the pancreas. Reflection on to posterior surface of first inch of duodenum, and over it to pylorus.

3. **Immediately above Pylorus.**—Great sac and omental bursa are here continuous through foramen epiploicum. **Great sac:** Begin on anterior aspect of free border of lesser omentum and pass to left. Anterior layer of lesser omentum; peritoneum on antero-superior surface of stomach; gastro-splenic ligament, spleen, lieno-renal ligament, kidney, diaphragm, falciform ligament, liver, diaphragm—all as in preceding section—over upper part of right kidney and on to vena cava in posterior wall of foramen epiploicum.

Omental Bursa.—Continue over vena cava to right crus; on to pancreas, right layers of lieno-renal and gastro-splenic ligaments, postero-inferior surface of stomach, posterior layer of lesser omentum, and round right free border of lesser omentum to starting-point for great sac, on its anterior aspect.

UROGENITAL APPARATUS

URINARY ORGANS

THE two **kidneys** extract constituents of *urine* from blood circulating in them ; pass it onwards by the **ureters** to the **bladder**, where it accumulates till it is expelled to the exterior through the **urethra**. Kidneys lie in upper part of abdomen proper ; ureters, in abdomen proper and in pelvis ; bladder, in pelvis ; urethra, in pelvis and perineum ; and, in the male, it traverses penis also.

Ren (Kidney).—Reddish brown in colour, bean-shaped, smooth ; about $4\frac{1}{2}$ in. long, $2\frac{1}{2}$ in. broad, $1\frac{1}{4}$ in. thick ; weighs about $4\frac{1}{2}$ oz. Relatively much larger in new-born than in adult. *Upper end*, nearer median plane than *lower end*, and usually bulkier. *Anterior surface*, directed ventrally and laterally, often raised in middle and sloping to each end, especially in left kidney. *Posterior surface*, directed dorsally and medially. *Lateral border*, convex. *Medial border*, concave, presents a vertical slit, called **hilum**, through which arteries and nerves enter ; lymphatics, veins, ureter leave. Hilum leads into space in interior, called **sinus renalis**, which contains fat, calyces, pelvis of ureter, and the vessels and nerves before their entrance into or after emergence from substance of kidney.

Position.—Kidneys lie on upper part of post. wall of abdomen behind peritoneum, opposite 12th TH. and upper 3 L. vertebræ. Right kidney usually reaches to level of upper border of last rib, left kidney to lower border of 11th rib ; but they may be on same level, or left may be lower. Lower end is $\frac{1}{2}$ in. to 2 in. above iliac crest, and is

farther away from median plane than upper. Hilum of right kidney is 2 inches, and lateral border 4 inches, from median plane, and the left a little nearer. Transpyloric plane cuts both above middle of hilum. Vertical lateral plane passes through kidney much nearer lateral border than hilum. Subcostal plane passes immediately below left kidney, but cuts lower end of right. Left kidney therefore is in epigastric and hypochondriac regions; right is slightly in umbilical and right lumbar as well.

In marking out the position of kidney, avoid numerous points of reference. Take a point just below transpyloric plane, about 2 inches from median plane, as representing middle of hilum, and map out the outline of a kidney, having regard to its size, shape and slope. On the back, map out the outline, keeping 2 inches from median plane, and placing upper end opposite upper border of 12th rib or lower border of 11th rib.

Relations.—A condensation of retro-peritoneal tissue, called *fascia renalis*, encloses kidney, together with suprarenal gland and a variable amount of fat (*capsula adiposa*), which is applied chiefly to its ends and borders. The two layers of fascia fuse just beyond suprarenal and fat at upper end, and beyond the fat at lateral border of kidney, and at varying distance below its lower end. Medially, the anterior layer passes in front of vena cava and aorta to join its fellow of opposite side; posterior layer fuses with fascia of psoas.

Posteriorly each kidney lies against psoas, quadratus and transversus, below; crus of diaphragm, lumbo-costal arches (arcuate ligaments) and part of diaphragm arising from them, above. Diaphragm separates it from pleura. Last thoracic, ilio hypogastric and ilio-inguinal nerves and subcostal vessels lie between it and quadratus lumborum.

Otherwise, except in regard to suprarenal, the kidneys differ in their relations. **Right Kidney:** *Anterior:* suprarenal gland, at upper end and upper part of medial border; 2nd part of duodenum, near hilum; right colic flexure, at lower end—all in direct contact. Liver, at upper part and part adjoining lateral border—separated by peritoneum. *Medial:* vena cava; ureter, which may be posterior. *Lateral:* asc. colon below, liver above. **Left Kidney:** *Anterior:* Suprarenal gland, as on right kidney; pancreas, with splenic vessels, across it above middle; left colic flexure, at lateral part of lower end—all in direct contact. Stomach above pancreas, jejunum below pancreas—separated by peritoneum. Spleen, at area adjoining upper part of lateral border—partly separated by peri-

toneum, partly connected by lieno-renal ligament. *Lateral*: spleen above, descending colon below. *Medial*: duodeno-jejunal flexure; inf. mesenteric vein; ureter, which may be behind.

Fibrous capsule of kidney splits at each lip of hilum, one layer going to form sheath for vessels and nerves outside hilum, the other becoming continuous with lining of sinus. Projecting into sinus are 12 to 15 small **renal papillæ**, each perforated at apex by **foramina papillaria**, through which urine exudes from kidney tubules into calyces. **Calyces renales**, about 12 in number, are short tubes which embrace renal papillæ, and are continuous, at bases of papillæ, with lining of sinus; one calyx may surround two or three papillæ. Calyces unite to form **pelvis renalis** (pelvis of ureter), the dilated beginning of ureter.

Kidney on section presents to naked eye a peripheral part—*substantia corticalis*—granular in appearance, and a *substantia medullaris*, consisting of **renal pyramids**, in which kidney tubules show as faint striations. Apices of pyramids are directed towards sinus, and several combine to form one renal papilla. Cortical substance sends in prolongations, called **columnæ renales**, between pyramids. In these the larger blood-vessels may be seen.

Two of the main branches of **renal art.** at hilum are anterior to ureter and posterior to veins. A third branch is posterior to ureter. *Accessory renal arteries* may enter kidney above or below hilum. **Nerves** to kidney, from renal plexus, come ultimately from 10th, 11th, 12th thoracic nerves.

Lymphatics end in lumbar glands at the side of aorta.

Ureter, about 10 inches long, begins in renal sinus as a dilatation, called **pelvis renalis** (pelvis of ureter), formed by union of 12 calyces. Pelvis issues from hilum, descends along medial margin of kidney or posterior to it, narrowing till, at lower end of kidney, it becomes **ureter proper**, which passes downwards and very slightly medially on psoas, to enter pelvis by crossing termination of common iliac or beginning of external iliac art. In pelvis it pursues an arched course, convexity of curve directed backwards and laterally, and it enters bladder at postero-lateral angle, $1\frac{1}{2}$ in. from neck of bladder and 2 in. from its fellow.

Ureters pierce bladder wall very obliquely so that their orifices are only 1 inch apart, and obliquity of passage serves the purpose of a valve.

Position of abdominal portion is indicated *in front* by line from subcostal plane, $1\frac{1}{2}$ to 2 in. from median plane, downwards to end of common iliac, *i.e.* junction of upper and middle thirds of line drawn from point $\frac{1}{2}$ in. below and to left of

umbilicus to a point on inguinal ligament, midway between iliac spine and symphysis. *Behind*: a line from point on subcostal plane, $1\frac{1}{2}$ -2 inches lateral to 2nd lumbar spine, down to post. sup. iliac spine, whose position is indicated by a dimple on skin.

Relations in Abdomen. — *Posterior, on both sides*: psoas, genito-femoral n., iliac art. *Anterior to right ureter*: renal vessels, 2nd and 3rd parts of duodenum; right colic vessels sometimes, ileo-colic and int. spermatic vess., peritoneum on post. abdominal wall; root of mesentery and sup. mesenteric vess.; ileum, as it crosses iliac artery. Vena cava is medial to right ureter. *Anterior to left ureter*: renal vessels, pancreas, attachment of transverse mesocolon, left colic, int. spermatic and sigmoid vessels, peritoneum on post. abd. wall, oblique attachment of pelvic mesocolon, and pelvic colon as ureter crosses iliac art. Duodeno-jejunal flexure and inf. mesenteric vein lie medial to left ureter. Aorta also is medial, but is some distance away.

In Pelvis.—It passes backwards, downwards, and laterally to level of ischial spine, having hypogastric artery and sacral plexus *behind*; peritoneum *medially*; obturator internus, obliterated umbilical art., obturator vessels and nerve, inferior vesical and mid. hemorrhoidal arteries *laterally*. From ischial spine it runs forwards and medially above levator ani and its fascia, below peritoneum, ductus deferens intervening. At entrance to bladder it is surrounded by plexus of veins and overlapped by upper end of seminal vesicle. **In female**, ovary is anterior to, and ampulla of uterine tube medial to, upper pelvic part, both separated by peritoneum. Lower part crosses below broad ligament and obliquely along side and front of upper end of vagina. Uterine art. crosses above it, between layers of broad ligament.

Arteries: from renal, int. spermatic, colic, vesical, middle hemorrhoidal. **Nerves**: from renal, spermatic and hypogastric plexuses. **Lymphatics** end in lumbar, common iliac and hypogastric glands.

Vesica Urinaria (Urinary Bladder).—Lies in anterior lower part of pelvis; in infancy, partly in abdomen also. When empty it possesses an apex, superior surface, two infero-lateral surfaces, a base or posterior surface. Surfaces are triangular in shape, and are separated by borders.

Vertex (Apex) lies posterior to upper margin of symphysis pubis. A fibrous cord *lig. umbilicale medium* or *urachus* (a remnant either of cloaca or of intra-abdominal part of allantois) extends from apex to umbilicus.

Superior surface is the only surface covered with peritoneum, except a small part of base. Pelvic colon and small intestine

rest on it, in male; uterus and intestine, in female. Lateral border is below and medial to obliterated umbilical artery, but comes into contact as bladder fills. Ureters enter its posterior angles. Peritoneum descends a short distance on base, near median plane, before reflection on to rectum, in male. In female, it is reflected from superior surface on to uterus.

Fundus (Base) is separated from rectum by ductus deferentes, vesiculæ seminales and fascia *in male*, by cervix uteri, vagina and fascia *in female*. Ducts and vesicles cover base except small triangular area covered with peritoneum between ducts, near upper border.

Infero-lateral surface, on each side, is in relation to pubis, levator ani, obturator internus, separated by fascia of bladder and of these muscles, and by fat in space of Retzius. Anterior rounded border, between these surfaces, is separated from symphysis by a pad of fat. Vesical plexus of veins lies on fundus and lateral surfaces, in and under cover of fascia.

Neck is most dependent part of bladder, and urethra emerges from it. Pubo-vesical ligaments connect it with pubis. *In the male*, when body is in erect posture, the neck lies a little below level of upper margin of symphysis and $2\frac{1}{2}$ in. posterior to it. It rests upon and is partly continuous with base of prostate, but separated peripherally by groove in which prostatico-vesical veins lie. *In female*, it rests on fascia superior of urogenital diaphragm (deep layer of triangular lig.) at level of line drawn from lower margin of symphysis to lower end of sacrum.

As bladder fills, the neck remains stationary. Superior wall rises, and, with other surfaces, increases in area and becomes more convex. Infero-lateral surfaces come into relation with greater area of side wall of pelvis, and with obturator vessels and nerve and ductus deferens. Borders become rounded and finally obliterated; bladder rises up out of pelvis, stripping peritoneum off anterior abdominal wall, so that bladder is in direct contact with it for $1\frac{1}{2}$ in. or more.

Interior of Bladder.—Mucous membrane is smooth when bladder is full; wrinkled when it is empty, except at **trigonum vesicæ**, where it is always smooth owing to close attachment to muscular wall of bladder. Trigone is situated at base of bladder. At upper or posterior angles are the orifices of ureters. At lower or anterior angle is **orificium urethræ internum**. Sides of triangle are 1 in. each when bladder is empty, $1\frac{1}{2}$ in. when full. **Uvula**

vesicæ is a projection forwards at posterior lip of urethral orifice, opposite middle lobe of prostate, enlargement of which increases size of uvula till it may block orifice. *Torus vesicalis* is a ridge of mucous membrane between orifices of ureters, produced by underlying bar of muscle; similar ridges may extend from urethral orifice to orifices of ureters. During life mucous membrane is straw-coloured, except over trigone, where it is pink, because the vessels show through it more readily.

Capacity of bladder in both sexes is very variable.

Arteries: superior and inferior vesical. **Veins** form a plexus drained into hypogastric (internal iliac). **Nerves**: through vesical plexuses, ultimately from upper lumbar and 3rd and 4th sacral. **Lymphatics** pass through small vesical glands on their way to hypogastric and iliac glands.

Urethra Muliebris.—Exceedingly dilatable. $1\frac{1}{2}$ inches long; curves downwards and forwards, below and posterior to symphysis pubis. Pierces both fasciæ of urogenital diaphragm, and, while between them, is surrounded by sphincter urethræ. Lies in close contact with anterior wall of vagina, and opens by prominent *external orifice* in vestibule of vagina, anterior to vaginal opening, between labia minora, 1 in. posterior to clitoris.

Urethra Virilis, about 8 in. long, conveys not only urine, but secretions of testes, seminal vesicles, prostate, bulbourethral glands (Cowper's), and minute urethral mucous glands. It describes an S-shaped curve, and is divided into prostatic, membranous and cavernous parts.

Prostatic Part, $1\frac{1}{4}$ inches long, tunnels prostate from its base to anterior border immediately above apex. Widest and most dilatable portion of urethra; widest in middle. *Crista urethralis* is a longitudinal elevation in its floor or posterior wall. Prostatic ducts open in groove (*prostatic sinus*) on each side of crista. At most prominent part, near lower end, there is the opening of *utricle prostaticus*, a diverticulum of mucous membrane leading upwards and backwards for $\frac{1}{4}$ – $\frac{1}{2}$ inch into substance of prostate, posterior to middle lobe. Ejaculatory ducts open at the margins of the opening.

Membranous Part.—Shortest, narrowest, and least dilatable part of urethra, except external orifice; $\frac{1}{2}$ – $\frac{3}{4}$ in. long. Curved with concavity forwards, 1 in. behind and below symphysis. Extends from apex of prostate to urethral bulb, piercing both fasciæ of urogenital diaphragm (triangular ligament). As it lies between the fasciæ it is surrounded

by sphincter urethræ ; and bulbo-urethral glands (Cowper's) are posterior to it, near its distal end.

Cavernous Part.—Enters deep surface of urethral bulb, $\frac{1}{2}$ in. anterior to its post. end ; traverses corpus cavernosum urethræ ; opens at extremity of glans penis as **orificium urethræ externum**, which is the narrowest and least dilatable point of the canal. Dilated in floor in bulb, and again in roof in glans (*fossa navicularis*). Lies nearer dorsal surface in bulb, nearer inferior surface in glans. *Lacune urethrales* are little recesses in its mucous membrane. Ducts of bulbo-urethral glands open into it, 1 inch in front of urogenital diaphragm.

Lymphatics of penile urethra end in deep subinguinal and external iliac glands ; of membranous and prostatic, and of female urethra, in ext. iliac and hypogastric glands.

MALE GENITAL ORGANS

Essential reproductive fluid is secreted by the two **testes**, which lie in the **scrotum**. From each testis, fluid passes into a tube, much coiled at first, called **epididymis**, straighter afterwards and called **ductus deferens**, which ascends from scrotum, traverses inguinal canal, descends to back of bladder, where it joins duct of **seminal vesicle** to form **ejaculatory duct**. Ejaculatory duct pierces prostate and opens into **urethra**, which receives also the secretions of **prostate**, which lies below bladder, and of **bulbo-urethral glands**, which lie in perineum. **Penis** is traversed by and supports urethra.

Scrotum.—Pendulous bag below and posterior to body of penis. **Skin**, dark and covered sparsely with hair, and divided by median ridge or *raphe*, which extends from scrotum backwards to anus and forwards on to penis. **Superficial fascia**, devoid of fat and largely replaced by *dartos* muscle, which sends backwards an imperfect *septum* to divide scrotum into 2 chambers. Walls of each chamber are formed by **coverings of testis**, derived from ant. abdominal wall, and named, from without inwards :—*ext. spermatic fascia*, from obliquus externus ; *cremasteric muscle and fascia*, from obliquus internus ; *internal spermatic* or infundibuliform *fascia*, from fascia transversalis. Skin and superficial fascia are common to both chambers. Wall of each chamber is lined with parietal layer of peritoneal *tunica vaginalis testis*.

Blood - vessels : scrotal branches of int. pudendal; ext. pudendal of femoral. **Nerves :** scrotal of pudendal; perineal branch of post. cutaneous (small sciatic); ilio-inguinal. **Lymphatics** end in superficial subinguinal glands.

Testis.—Whitish in colour, oval in shape. Superior and inferior *extremities*. Lateral and medial *surfaces*. Anterior and posterior *borders*. $1\frac{1}{2}$ in. long, 1 in. broad, $\frac{3}{4}$ in. in thickness from side to side. Long axis directed upwards, forwards and laterally. Lateral surface looks laterally and backwards. Left testis reaches lower level than right. Epididymis and lower end of spermatic cord are attached to posterior border, through which vessels and nerves enter testis.

Tunica vaginalis testis, a closed sac of serous membrane derived from peritoneum, lines walls of scrotal chamber (*parietal lamina*), and is reflected from posterior wall to give a covering (*visceral layer*) to epididymis, testis, front and sides of lower end of spermatic cord, above the testis. From lateral aspect, it is tucked in between epididymis and testis, forming a recess called **sinus epididymidis** (digital fossa).

Epididymis lies along posterior border of testis, lateral to lower end of spermatic cord and ductus deferens, with which it is in direct contact. Its upper end or **caput** is enlarged, overhangs and lies in direct contact with upper end of testis, with which it is connected by ductuli efferentes. **Body** is separated from the testis by the sinus epididymidis. **Cauda** or lower end is in direct contact with testis, near lower end. Epididymis consists of an exceedingly coiled tube—**ductus epididymidis**—about 20 feet long, which is continuous with ductus deferens at cauda epididymidis.

Structure of Testis—Beneath serous covering is a dense, white fibrous coat, called **tunica albuginea**, which is thickened and projected into testis, posteriorly, as **mediastinum testis**, from which **septula** pass to the tunica albuginea on the surfaces and ant. border, and imperfectly divide testis into **lobules**. Much coiled **tubuli seminiferi contorti**, which secrete semen, lie in lobules. These tubules, about 600 in number, each about 2 feet long, unite to form **tubuli recti**, which enter mediastinum and join one another to form **rete testis**. From the rete, 15 to 20 **ductuli efferentes** pass out of mediastinum into caput epididymidis, where each is coiled on itself to form a little cone, called **lobulus epididymidis**, before entering tube of epididymis.

Blood-Vessels.—Int. spermatic art., from aorta, anastomoses in cord with art. to ductus deferens and ext. spermatic (cremasteric). Veins form pampiniform plexus, from which spermatic vein arises. On right side it ends in v. cava inferior; on left side, in renal. **Lymphatics** end in lumbar glands. **Nerves**, from aortic and renal plexuses; ultimately from 10th thoracic segment to testis, 11th and 12th TH. and 1st L. to epididymis.

Appendices testis are small sessile or pedunculated bodies found on caput epididymidis or on upper end of testis. One is a remnant of Müllerian duct and corresponds to fimbriated end of uterine tube; the other may be a Wolffian tubule, or upper end of Wolffian duct. **Paradidymis**—a small collection of coiled tubules found above caput, in front of spermatic cord—is a remnant of mesonephros.

Ductus deferens (Vas deferens) is direct continuation of ductus epididymidis. Ascends to abdomen in spermatic cord, runs along side wall of pelvis, beneath peritoneum, to the level of the ischial spine; turns medially to reach base of bladder, where it joins duct of seminal vesicle to form ejaculatory duct.

It begins at lower end of epididymis; runs upwards, posterior to testis, on medial side of epididymis; ascends to subcutaneous abdominal ring and traverses inguinal canal, as a constituent of spermatic cord, in posterior part of which it is readily palpable in living or dead subject, owing to firm cord-like character. Leaves the other constituents of cord at abdominal inguinal ring; passes medially and backwards, behind inf. epigastric vessels, across ext. iliac vessels, and enters pelvis. In pelvis, it runs backwards and medially, across obliterated umbilical art., obturator vessels and nerve, vesical vessels and urter, to reach sacro-genital fold, at level of ischial spine, where it turns sharply medially, over upper end of seminal vesicle, to reach base of bladder. From abdominal inguinal ring to bladder it lies immediately beneath peritoneum. At bladder it enters pelvic fascia; runs downwards on base of bladder, close to median plane and its fellow, medial to seminal vesicle, in front of rectum. Here it is dilated to form *ampulla*, in which semen accumulates. Lower end of ampulla narrows and joins duct of seminal vesicle to form ejaculatory duct.

Blood-vessels: art. deferentialis from sup. or inf. vesical; branches from middle hæmorrhoidal. **Nerves**: from hypogastric plexus. **Lymphatics** end in external iliac and hypogastric glands.

Funiculus spermaticus (Spermatic cord) extends from abdominal inguinal ring to posterior border of testis. It consists of ductus deferens with its artery, the rudiment of processus vaginalis, and the structures essential to

nutrition of testis—viz., int. spermatic art., pampiniform plexus of veins, testicular lymphatics and nerves—all enclosed in **coverings** prolonged over them and over testis from constituents of abdominal wall—ext. spermatic fascia, cremasteric muscle and fascia, and int. spermatic fascia.

Accompanying and supplying the coverings are ext. spermatic vessels and nerve (cremasteric vessels and genital branch of genito-crural nerve).

Relations.—In inguinal canal—*See* Walls of inguinal canal. **Between Inguinal Canal and Testis.**—*Anterior*: skin, superficial fasciæ, superficial ext. pudendal vessels, testis. *Posterior*: Origins of adductor longus and gracilis, deep ext. pudendal vessels, posterior wall of scrotum. It may touch upper medial angle of pectineus.

Vesiculæ seminales lie on base of bladder, enclosed in pelvic fascia. Each is a branched, sacculated tube, 6 in. long, coiled to form a piriform body, 2 in. long, which tapers to lower end, where tube is narrowed down to form slender ductus excretorius.

Long axis is directed upwards, backwards and laterally, so that medial border looks more upwards than medially when bladder is empty, but is more vertical when bladder is full. **Lower ends** lie at base of prostate and are separated by ductus deferentes only. **Upper ends** are 2 in. or more apart; upper end of each lies in sacro-genital fold of peritoneum, *below* ductus deferens, overlapping entrance of ureter into bladder *anteriorly*, while *posteriorly* it is in relation to levator ani, at side of rectum, opposite ischial spine. **Lateral border** is supported by levator ani. Ductus deferens lies along **medial border**. **Anterior surface** is related to bladder; **posterior surface** is related to rectum.

Blood-vessels: from vesical and middle hæmorrhoidal. **Nerves**: from hypogastric plexus. **Lymphatics** end in hypogastric (int. iliac) and ext. iliac glands.

Ductus ejaculatorius is formed by the union of ductus deferens and excretory duct of seminal vesicle, at base of prostate. It is $\frac{3}{4}$ in. long and very slender; lies close to its fellow, at median plane: pierces prostate to open into prostatic urethra at the mouth of utriculus prostaticus (sinus pocularis). Its lower part passes by the side of utriculus.

Prostate lies below bladder, anterior to lower end of rectum. Partly glandular, partly fibro-muscular. Fibrous condensation at surface is called its **capsule**. Possesses

apex, base, anterior surface or border, a posterior and 2 lateral surfaces. Length from base to apex, $1\frac{1}{4}$ in. Greatest breadth, $1\frac{1}{4}$ - $1\frac{1}{2}$ in. Greatest antero-posterior diameter, 1 in. Urethra traverses it from base to anterior border near apex. Ejaculatory ducts traverse its upper half, behind urethra. Ducts of its glandular substance open into prostatic sinus at side of urethral crest. Prostatic utricle extends upwards and backwards, from urethra, into its substance for $\frac{1}{4}$ to $\frac{1}{2}$ in.

Two lateral lobes and a middle lobe, not marked off from one another. Middle lobe is merely that part which lies between urethra anteriorly and ejaculatory ducts and prostatic utricle posteriorly. It produces elevation in interior of bladder, at urethral orifice, called *uvula vesicæ*.

Relations.—Encased in sheath of pelvic fascia. Thickened bands of fascia—pubo-prostatic ligaments—pass from back of pubis to be connected with sheath and with fascia at neck of bladder—pubo-vesical ligaments. Pudendal (prostatic) plexus of veins (most dense anteriorly, where it receives dorsal vein of penis) lies in substance of sheath, and between it and prostate.

Base is partly continuous with neck of bladder and is partly separated by a groove, which lodges veins. **Apex** is $1\frac{1}{2}$ inches above anus, and rests on superior fascia of urogenital diaphragm. Rounded **anterior border** is separated from symphysis and space of Retzius by venous plexus and pubo-prostatic ligaments. Convex **lateral surfaces** are supported by levatores ani; and anterior borders of levatores clasp prostate near its apex. Flat **posterior surface** rests against lower part of rectum.

Arteries: from inferior vesical and middle hæmorrhoidal. **Venous plexus** is drained into hypogastric (int. iliac). **Nerves:** from hypogastric plexus. **Lymphatics** end in vesical, ext. iliac, hypogastric, sacral, and hæmorrhoidal glands.

Bulbo - urethral Glands (Cowper's Glands).—Two small glands, each the size of a pea in young subject, very small in old. They lie between fasciæ of urogenital diaphragm (layers of triangular lig.), close to membranous urethra. Their **ducts** pass through urethral opening of fascia inferior of diaphragm, enter bulb of penis and run along the side of urethra for nearly an inch before entering it.

Urethra. See p. 479.

Penis.—(1) Body; (2) Root, buried in perineum; (3) Glans, the conical extremity.

Body of penis is composed of two *corpora cavernosa penis* and a *corpus cavernosum urethræ*, each consisting of dense

fibrous coat, enclosing spongework of fibrous tissue, spaces of which are distended with blood during erection. All three are enclosed in loose fibrous sheath, called *fascia penis*. *Lig. suspensorium penis*, a triangular fibrous band, is attached by apex to ant. surface of symphysis pubis, while its base divides and becomes continuous with fascia penis on each side. Corp. cav. penis are fused. Fused medial part of their coats is interrupted by slits, and is called **septum pectiniforme**. Corpus cav. urethræ lies in shallow groove on inferior aspect of fused corp. cavernosa penis.

Posteriorly, the corpora separate and form **root of penis**. Diverging posterior ends of corp. cav. penis are called **crura penis**. Each crus is attached to groove on perineal aspect of conjoined rami of pubis and ischium, is covered by ischio-cavernosus (erector penis), and tapers to a point posteriorly.

Corpus cav. urethræ extends backwards into perineum. Its posterior free end is enlarged and called **bulbus urethræ**, and is adherent to inferior fascia of urogenital diaphragm (triangular lig.); bulbo-cavernosus muscle (ejaculator urinæ) covers it. Anteriorly, corp. cav. urethræ is greatly enlarged to form **glans penis**, in which pointed anterior ends of corp. cav. penis are imbedded. Projecting margin of base of glans is called **corona glandis**. Constriction behind glans is called the **neck**. Urethra enters deep surface of bulbus and traverses whole length of corpus cavernosum urethræ, and in glans lies nearer inferior surface than dorsal.

Skin of penis is devoid of hairs, except near its root. On glans, it is exceedingly thin and adherent; over body of penis, it is thin and freely movable. At neck, it is reflected forwards for variable distance over glans as a free fold, called **præputium** (prepuce). A secondary fold, called **frenulum præputii**, connects prepuce with glans, just below orifice of urethra.

Superficial fascia of penis is thin and contains no fat.

Smegma præputii is a material, with characteristic odour, found between prepuce and glans. It consists of desquamated and broken-down epithelial cells, and secretion of sebaceous glands on glans and prepuce.

Arteries: *On each side*; Artery of bulb, profunda art. to corp. cav. penis, and dorsal artery of penis, from pudendal; these six are cut in a transverse section of penis. Superficial ext. pudendal of femoral, these two, in addition, are cut in section near root. **Veins** corresponding, but dorsal veins are median in position, a *superficial* dividing

to end, on each side, in superficial ext. pudendal, and a *deep*, beneath fascia penis, ending in pudendal (prostatic) plexus. **Nerves**: *To skin and fasciæ*: dorsal nerve of penis, scrotal branches of pudendal and ilio-inguinal, perineal branch of post. cutaneous of thigh (small sciatic). *To substance of corpora*: cavernous plexuses of sympathetic. **Lymphatics**: from skin, to superficial subinguinal glands; from deep parts and glans, to superficial and deep subinguinal glands.

FEMALE GENITAL ORGANS

The two **ovaries** shed *ova* into peritoneal cavity, from which they pass into the 2 **uterine (Fallopian) tubes**, where they may be fertilised and begin development. From uterine tube the ovum is sent, at very early stage, into **uterus** to continue development; and, when intra-uterine development is completed, it is expelled, through **vagina**, to the exterior at **pudendum muliebre** (vulva).

Ovaries, uterine tubes and uterus lie in the pelvis; vagina lies in pelvis and in perineum.

Ovarium.—Each **ovary**, in size and shape like a large almond, long axis vertical, lies on the side wall of pelvis, between ureter and broad ligament. It is connected to broad lig. by short fold, called *meso-ovarium*, the endothelium of which is continuous with epithelial covering of ovary; between its layers, vessels and nerves pass to the ovary.

Blunt **upper end** of ovary lies below level of ext. iliac vessels and obliterated umbilical art. Uterine tube curves round it, and it is therefore called *extremitas tubaria*. Suspensory lig. of ovary (*i.e.* lateral part of free edge of broad lig. containing ovarian vessels and nerves) connects it with peritoneum covering iliac vessels. **Lower end** is connected by lig. ovarii with uterus, and is called *extremitas uterina*. **Posterior border** is free, lies anterior to ureter and hypogastric artery, and is in contact with end of uterine tube. **Anterior border** gives attachment to meso-ovarium. Vessels and nerves enter at this border through a cleft called the *hilum*. **Medial surface**, largely overlapped by uterine tube, and covered by pelvic colon or small intestine. **Lateral surface** lies in *fossa ovarica*, the floor of which is formed by peritoneum which separates ovary from obturator vessels and nerve, and obturator internus muscle.

Arteries: ovarian from aorta; branches from uterine. **Veins** form pampiniform plexus, from which ovarian vein issues to end in v. cava on right side, renal on left. **Nerves**: from aortic and renal plexuses (ultimately 10 TH.). **Lymphatics** end in lumbar glands: some from right ovary are said to end in appendicular gland.

Tubæ Uterinæ (Fallopian Tubes).—Each **uterine tube** is 4 in. long. One end opens into upper angle of uterine cavity ; other end opens into peritoneal cavity. Part is imbedded in wall of uterus. Emerges from uterus at upper angle, between body and fundus ; enters broad ligament, and lies in its upper or anterior free edge. Pierces ligament at side of pelvis and curls round upper end of ovary, overlapping its medial surface.

Medial inch, outside uterus, is narrow, straight, closely adherent to peritoneal covering, and is called **isthmus**. Remainder is larger and slightly convoluted, more loosely connected with peritoneum, and is called **ampulla**. Abdominal end is the funnel-shaped **infundibulum**, which is broken up into a number of processes called **fimbriæ**. One of them, longer than others and grooved, is attached to ovary and is called **fimbria ovarica**. Termination of uterine tube, behind ovary, is separated by peritoneum from medial aspect of ureter.

Blood-supply, from uterine and ovarian vessels. **Nerves**, from uterine and ovarian plexuses—ultimately from 11, 12 TH., 1 L. **Lymphatics** end in lumbar glands.

Ep-oöphoron.—One longitudinal tubule and several transverse ones opening into it from below. These lie in mesosalpinx, between uterine tube and ovary. Longitudinal is a remnant of Wolffian duct and represents male duct of epididymis. Transverse are remnants of mesonephric tubules and represent ductuli efferentes and lobuli epididymidis.

Par-oöphoron, a few tubules lying nearer uterus, derived from mesonephros, corresponds to paradidymis. **Appendices vesiculosi**, one or more small pedunculated cysts found near infundibulum, derived from upper end of Wolffian duct.

Uterus lies between rectum and bladder. Piriform in shape ; broad end directed forwards and upwards. 3 in. long, 2 in. broad, 1 in. in antero-posterior thickness.

Fundus is part above level of entrance of uterine tubes. **Cervix** is lowest inch, more cylindrical than the rest, and opens into vagina. **Body** is the intervening portion, marked off from cervix by slight constriction called **isthmus**.

Long axis of uterus is directed forwards and upwards, parallel to axis of plane of superior aperture of pelvis, at right angles to vagina, in normal position of *anteversion*. When bladder is overdistended, uterus is raised up into line with vagina (*retroversion*). Body is more pliant than cervix and forms angle with it, open forwards. This is normal *anteflexion*. Uterus is never quite median. Usually it inclines

to the right, and is twisted so that vesical surface looks slightly towards the right, as well as downwards and forwards.

Anterior or vesical surface, slightly convex, is in relation to bladder, and is covered with peritoneum as far down as isthmus. **Posterior or intestinal surface**, much more convex than anterior. Covered with peritoneum all the way down to vagina. Pelvic colon or small intestine rests on it.

Each **lateral border** is connected with "broad ligament," and, between its layers, with lig. ovarii and lig. teres, branches of uterine art. and uterine venous plexus. These are imbedded in fatty tissue, called *parametrium*, which is most abundant near cervix and vagina.

Cervix uteri is inserted into upper end of anterior wall of vagina, and consists of: (1) **intra-vaginal** portion, projecting into vagina; (2) **intra-mural** portion, surrounded by vaginal wall; (3) **supra-vaginal** portion, covered with peritoneum *posteriorly*, separated from bladder by fatty tissue *anteriorly*, connected *laterally* with broad ligament and parametrium, containing blood-vessels.

Cavity of uterus is a chink between anterior and posterior walls of body. $1\frac{1}{2}$ in. long; triangular in outline, uterine tubes opening into basal angles, apex continuous with cervical canal. Mucous membrane is smooth.

Canalis cervicis uteri.—1 in. long; spindle-shaped. Upper end opens into cavity of uterus as *orificium internum uteri*. Lower end—*orificium externum uteri*—opens into vagina. Part of cervix bounding ext. orifice anteriorly is called *labium anterius*, and that posteriorly, *labium posterius*.

Lig. ovarii proprium (remnant of upper part of gubernaculum of ovary), 1-1 $\frac{1}{2}$ inches long, is attached to uterus below and posterior to entrance of tube, and extends to lower end of ovary, raising a peritoneal ridge on posterior surface of broad ligament.

Lig. teres uteri (remnant of lower part of gubernaculum), attached to uterus below and anterior to entrance of tube, extends laterally and forwards, raising a ridge on anterior surface of broad ligament. It crosses vesical art., obturator vessels and nerve, obliterated umbilical art., ext. iliac vein, and, reaching ext. iliac artery behind inf. epigastric, it enters and traverses inguinal canal, and it ends in skin and fascia of labium majus.

Mucous membrane in cervical canal is raised into median longitudinal folds in front and behind. Secondary folds pass upwards and laterally from these. Folds are named *plicæ palmatæ* (arbor vitae), and are usually absent after first pregnancy.

Arteries of uterus : uterine, and branches of ovarian. **Veins** end in hypogastric (internal iliac). **Nerves** : utero-vaginal plexus, vesical plexus, and directly from hypogastric plexus ; ultimately from 10, 11, 12 TH. ; 1 L. ; 2, 3, 4 S. **Lymphatics** : from body and fundus end in lumbar, external iliac, and superficial subinguinal ; from cervix, to hypogastric, iliac, ano-rectal, and sacral glands.

Vagina.—Lies in lower part of pelvis minor and in perineum. Long axis is parallel to plane of sup. aperture of pelvis and at right angles to axis of uterus. *Anterior wall*, 3 inches long, and *posterior wall*, $3\frac{1}{2}$ inches long, lie in contact except at wide upper end, where cervix uteri projects into cavity of vagina, through uppermost part of anterior wall. Space between intra-vaginal portion of cervix and walls of vagina is divided into **anterior**, **lateral** and **posterior fornices**, of which post. is deepest, ant. shallowest. Objects lying in recto-uterine peritoneal pouch may be felt through post. fornix. Lateral fornix lies below parametrium and medial angle of broad ligament, and is crossed antero-posteriorly by ureter, and latero-medially, above ureter, by uterine artery.

Lower end of vagina is partially closed, in virgin, by two crescentic folds of mucous membrane, called **hymen**. After rupture the fragments persist as little nodules, called **carunculæ hymenales**. Vagina is surrounded by fascia in pelvis, is related *laterally* to levator ani ; passes downwards between ant. borders of levatores ; pierces both fasciæ of urogenital diaphragm (two layers of triangular lig.), and at termination is related, on each side, to bulb of vestibule and vestibular gland. Anterior borders of levatores ani form a second sphincter. Bladder and urethra are *anterior*. *Posterior* surface is covered, in its upper $\frac{1}{4}$ -1 inch, by peritoneum ; below that, it lies in contact with rectum ; and inferiorly it is separated by "perineal body" from anal canal.

Arteries : uterine, vaginal, middle hæmorrhoidal, internal pudendal. **Nerves** : utero-vaginal and vesical plexuses, and from 3rd and 4th sacral directly. **Lymphatics** from upper part end in external iliac glands ; from middle part, in hypogastric and ano-rectal glands ; from lower part, in superficial subinguinal glands.

Bulbus Vestibuli —Erectile tissue. Corresponds, on each side, to a half of male bulbus urethræ. Lies on fascia inferior of urogenital diaphragm (triangular ligament), at side of end of vagina, and is covered by bulbo-cavernosus muscle (sphincter vaginæ). Anterior end narrows to form **pars intermedia**, which joins with its fellow in front of urethra to be prolonged onwards to under surface of clitoris and to end in glans clitoridis. **Artery**, a branch of internal pudendal.

Glandulæ vestibulares majores (Bartholin) correspond to male bulbo-urethral glands, but each lies on superficial surface of fascia inferior of urogenital diaphragm, at side of vagina, overlapped by posterior end of bulb and covered by bulbo-cavernosus. Duct opens between orifice of vagina and attachment of labium minus.

Pudendum muliebre, or Vulva, comprises the two labia majora and the parts in the interval between them.

Labia Majora.—Correspond to scrotum. Enclose between them **rima pudendi** (urogenital cleft), into which vagina and urethra open. Labia are in contact and hide the parts in cleft. Each is large fold of skin enclosing fat; covered with hair laterally, smooth and moist medially. They are united posteriorly by **commissura posterior**, an ill-defined fold of skin in front of anus, and anteriorly by **commissura anterior** (mons Veneris), which is covered with hair, and is prominent, owing to underlying fat on anterior surface of symphysis pubis. Lig. teres uteri ends in labium majus. **Arteries**: labial branches of int. and ext. pudendal. **Nerves**: ilio-inguinal, pudendal, perineal branch of posterior cutaneous (small sciatic). **Lymphatics** end in superficial subinguinal glands.

Labia Minora.—Small folds of skin lying longitudinally between labia majora. They end posteriorly either by joining l. majora or uniting behind vaginal opening to form **frenulum labiorum** (fourchette). Anteriorly each divides into two. Medial divisions unite and join glans clitoridis to form **frenulum clitoridis**; lateral divisions unite over glans to form **præputium clitoridis**. **Fossa navicularis** is the interval between frenulum labiorum and vaginal opening. **Vestibulum vaginæ** is the space between labia minora, in front of vagina, behind clitoris. *External urethral orifice* lies in vestibule, 1 inch posterior to clitoris, close to vagina.

Clitoris lies in anterior part of rima pudendi. Corresponds to penis. Has homologous parts and nerves and vascular supply. Differs in that it is small and is not traversed by urethra.

MAMMÆ

Mammary Glands are accessory to reproductive system. Rudimentary in male. Begin to enlarge, in female, after puberty. Enlarge greatly during pregnancy, and still more after parturition. Atrophy in old age. Each lies in superficial fascia on ant. surface of thorax, from 2nd to 6th rib, and from side of sternum almost to mid-axillary line, upon pectoralis major and serratus anterior. At lower border of pectoralis a process extends up into axilla as high as 3rd rib.

Papilla mammæ (Nipple) projects from it, a little below

middle, opposite 4th intercostal space, and is surrounded by pigmented patch, called *areola*.

Corpus mammæ is made up of 15 to 20 lobes of gland substance, which converge towards nipple and are subdivided peripherally. Fibrous tissue surrounding them sends processes to be attached to skin. Fat covers the gland and fills up inequalities of its surface ; is most abundant in lower lateral part, but is absent from areola and nipple. **Ductus lactiferus** of each lobe ends on summit of nipple. Under areola it is dilated — *sinus lactiferus*.

Arteries : from internal mammary, lateral thoracic, intercostals. **Veins** end in internal mammary and axillary, a few in ext. jugular. **Nerves** : from 4th, 5th, 6th intercostals. **Lymphatics** : from lateral $\frac{2}{3}$, end in pectoral glands and thence in lateral axillary ; from medial $\frac{1}{3}$, in sternal glands ; from deep aspect, in infra-clavicular and in lower deep cervical glands. Lymph vessels of the 2 mammæ communicate across median plane ; and some, on each side, pass down to the angle between rectus abdominis and 9th cartilage, enter abdomen and anastomose with lymph vessels in extra-peritoneal tissue.

DUCTLESS GLANDS

Lymph glands, see p. 313; **pineal body**, see p. 337; **hypophysis** (pituitary body), see p. 335.

Lien (Spleen).—5 in. long, 3 in. broad, $1\frac{1}{2}$ -2 in. thick. Lies obliquely, behind stomach, in left hypochondrium and adjoining part of epigastrium, opposite 9th, 10th, 11th ribs. Long axis coincides with that of 10th; posterior border corresponds to lower border of 11th; anterior projecting angle reaches the level of mid-axillary line.

Surfaces. — **Diaphragmatic**: large, convex; separated by diaphragm (1) from lower intercostal muscles, (2) from pleura above that, and, in its upper part, (3) from lung. **Gastric**: concave; separated from postero-inferior surface of stomach, near fundus, by gastro-splenic ligament (omentum). **Renal**: slightly concave; applied to upper part of anterior surface of left kidney, near lateral border. **Base** rests on splenic flexure of colon and phrenico-colic ligament.

Borders: **Anterior** is sharp and *notched*, and ends below in prominent *anterior angle*. **Posterior** and **inferior**, smooth and blunt. Borders separating gastric and renal surfaces and base are rounded off. At their meeting-point, and encroaching on gastric surface, is a depression for tail of pancreas.

Hilum, interrupted and irregular, is situated on posterior part of gastric surface.

Spleen is almost completely surrounded by peritoneum. Gastro-splenic and lieno-renal ligaments, attached in neighbourhood of hilum, connect it with stomach and kidney.

Blood-vessels: Splenic branch of coeliac artery. Splenic vein joins v. portæ. **Nerves:** from splenic plexus. **Lymphatics** end in splenic glands near hilum, and in left supra-pancreatic glands.

Small, globular **accessory spleens** are sometimes found in neighbourhood of spleen.

Suprarenal Glands.—Each lies in epigastrium, on medial part of upper end of corresponding kidney and adjoining crus of diaphragm, opposite medial end of 11th intercostal space and 12th rib. **Right** is behind liver; **left** is behind stomach; between the two are the crura, aorta, cœliac artery, cœliac plexus and ganglia, and the inferior vena cava.

Right gland, triangular. Anterior surface, devoid of peritoneum, except a small part below; covered by liver laterally, overlapped by v. cava medially. **Hilum** (where vein issues), near upper end. **Left gland**, semilunar. Ant. surface, covered by splenic art. and pancreas below, above by stomach, separated by peritoneum of omental bursa (lesser sac). **Hilum**, near lower end. **Arteries**: from aorta, inferior phrenic, and renal. **Vein** ends in vena cava on right side, in renal on left. **Nerves** (very numerous): from cœliac plexus and ganglia. **Lymphatics** end in lumbar and posterior mediastinal glands.

Suprarenal glands are almost as large in new-born as in adult.

Thymus (p. 426).—Large in fœtus and young child; largest at end of 2nd year. After puberty it is represented usually by fibrous and fatty remnants, in front of large vessels and trachea, in root of neck and upper part of thorax.

Thyroid Gland lies in lower part of front of neck, in relation to trachea and larynx; ensheathed in pretracheal fascia, by which it is attached to larynx; consists of two lateral lobes united by isthmus. (See also p. 210.)

Lateral Lobe.—Pyramidal, apex upwards. *Superficial surface*: covered by sterno-thyroid, omo-hyoid, sterno-hyoid, overlapped by sterno-mastoid. *Deep surface*: in relation to lower part of larynx and pharynx; upper 5 or 6 rings of trachea, œsophagus and common carotid art. **Isthmus** lies on 2nd, 3rd, 4th rings of trachea, covered by fasciæ and partly by sterno-hyoids. **Lobus pyramidalis**, a small process often found projecting upwards from isthmus, usually on left side, and connected with hyoid bone by levator glandulæ thyreoideæ.

Parathyroid Glands.—4 small bodies, each about $\frac{1}{4}$ inch long, lie inside fascial sheath of thyroid gland but outside its capsule, in relation to branches of thyroid arteries. **Superior**—on each side, on longus colli, behind upper end of œsophagus; **inferior**—on trachea, at or below lower border of lateral lobe of thyroid.

Glomus caroticum (carotid body), minute oval body, $\frac{1}{8}$ inch long, found on back of bifurcation of common carotid; consists of fibrous capsule enclosing nodules of polyhedral cells, a network of capillaries and sympathetic filaments. **Glomus coccygeum** (coccygeal body) is a similar body found on pelvic surface of coccyx.

EMBRYOLOGY

FORMATION OF THE EMBRYO

THE mature ovum is the **female gamete**. The spermatozoön is the **male gamete**. *Fertilisation* is the union of male and female gametes.

Fertilised ovum is the **zygote**, which divides again and again to produce a mass of cells called **morula**, from which both embryo and embryonic appendages are developed. Outermost layer of morula is the **trophoblast**; remainder is the **inner cell mass**. They become separated by fluid, except at one pole; and morula becomes the **blastula**, which consists of a single-celled sac, the *trophoblast*, enclosing fluid and a collection of cells, the *inner cell mass*, adherent to the trophoblast at one pole.

Cavities appear in inner cell mass and divide it into two sacs, placed one above the other and adherent to one another; the upper sac is adherent by its upper surface to trophoblast also; it encloses the **amniotic cavity**; and cells forming its walls are called **ectoderm**. The cells of the other sac are called **entoderm**, and it develops into (1) **primitive** alimentary canal and (2) **yolk sac**, or umbilical vesicle.

The region where the sacs are adherent to one another is called the **embryonic area**, because the embryo develops there. Embryonic area is a plate consisting of a dorsal or upper layer of ectoderm and a ventral layer of entoderm. At first it is circular, and then egg-shaped, the large end being the cephalic end.

In **human** zygote, as soon as embryonic area is defined, mesoderm is present in both intra- and extra-embryonic regions. It fills the space between trophoblast and the inner two sacs, and passes in between the two sacs, and therefore is present to some extent in embryonic area. This condition seems to be peculiar to human development. Soon after the embryonic area becomes distinct a median linear streak is visible in its caudal part. This is the **primitive streak**. In it, ectoderm and mesoderm are closely bound

together; and it represents seat of origin of mesoderm in most mammals. Along surface of streak is a groove called **primitive groove**. This is deepest at its cephalic end, where it communicates with cavity of entoderm by an aperture called **neurenteric canal**.

FOLDING OFF OF EMBRYO

Growth in embryonic area is rapid, and is such as to increase its area rather than its thickness; but growth at its periphery is very little. Therefore the area is ballooned up into amniotic cavity, and falls over its slow-growing margins, forming a large **cephalic fold** and small **lateral folds**.

The **caudal fold**, in the human, does not appear till later, because posterior end of embryonic area is closely attached by thin layer of mesoderm to the mesoderm on inner surface of trophoblast. As this connecting layer of mesoderm becomes stretched, coincidently with increase of amnion and its cavity, the tail fold becomes evident, and posterior end of embryonic area sweeps round, on ventral aspect of embryo, to umbilicus, and so completes ventral wall from tail to umbilicus.

While caudal part of embryonic area is prevented from rotating by its connection with trophoblast, a diverticulum from yolk sac extends into mesoderm which is caudal to it. This is rudiment of **allantois**, and along it umbilical arteries pass. This portion of zygote forms the **body stalk**.

Folds include all the layers of the embryo. The portion of entoderm included, with its cavity and covering of mesoderm, forms **primitive alimentary canal**. The part of entoderm, with its mesodermal covering, not included forms **umbilical vesicle** or **yolk sac**. The wide communication between canal and vesicle is surrounded by the **umbilicus**, whose margins, therefore, are formed by the periphery of the embryonic area.

Portion included in cephalic fold is called **fore-gut**, and from it are formed pharynx, oesophagus, stomach and greater part of duodenum. Portion in caudal fold is the **hind-gut**; part opposite umbilicus is the **mid-gut**. These two parts form the rest of alimentary canal, without any hard and fast line between them.

FORMATION OF NEURAL TUBE

While embryo is being folded off a median longitudinal groove, called **neural groove**, appears on dorsal surface, on cephalic side of primitive streak. It grows caudalwards and absorbs cephalic end of primitive streak. Remainder of primitive streak persists to form cloacal membrane and ventral wall of body as far as umbilicus.

Neural groove is bounded by ectodermal **medullary folds**, which,

from the first, meet at its cephalic end, and afterwards at its caudal end. These folds rise up, their edges turn medially, meet and fuse to convert groove into the **neural tube**. Embryo, therefore, encloses an ectodermal neural tube and an entodermal alimentary tube, and a space, bounded by mesoderm, called the embryonic *cœlom* (p. 497).

Along line of fusion, the ectodermal neural tube is connected, for a time, with surface ectoderm by a ridge called **neural crest**. Crest separates from surface ectoderm, but remains connected with neural tube; and from it are developed: (1) the ganglia of spinal and cerebral nerves and of sympathetic, (2) medulla of suprarenal gland and other chromaffin tissues.

Three dilatations appear on cephalic end of neural tube, called **primary cerebral vesicles**. The **anterior** forms prosencephalon (fore-brain), lateral and 3rd ventricles; **middle** forms mesencephalon (mid-brain) and aquæductus cerebri (Sylvius); **posterior** forms rhombencephalon (hind-brain), 4th ventricle and central canal of lower half of medulla oblongata. Remainder of tube forms medulla spinalis (spinal cord) and its central canal. Before neural folds are closed the neurenteric canal has disappeared, in human embryo.

FORMATION OF NOTOCHORD

The **notochord** is the primitive vertebral column, and is formed from entoderm. A linear longitudinal strip of entoderm thickens and then separates as a solid rod of cells, lying between neural tube and primitive alimentary canal, extending from cephalic end of primitive mesencephalon to cephalic end of primitive groove. It becomes surrounded by the mesoderm which forms basilar part of skull, vertebral column, and membranes of brain and medulla spinalis. It can be traced through the parts which, in adult, become post. part of body of sphenoid, basi-occiput, lig. apicis dentis (suspensory), dens (odontoid process), bodies of vertebræ, down to tip of coccyx. As mesoderm develops, the notochord becomes nodulated. Nodules form pulp of intervertebral fibro-cartilages. The rest begins to disappear during 2nd month of fetal life.

(It is possible that the notochord is developed from mesoderm, which sinks into entoderm and grows out of it again.)

Derivatives of Mesoderm, Ectoderm and Entoderm

Extra-embryonic mesoderm at first fills space within trophoblast, but, later, becomes divided into 2 layers. One layer covers entodermal sac and is called **splanchnic mesoderm**. The other lines trophoblast and is called **somatic mesoderm**. The cavity between the layers is called the **extra-embryonic cœlom**.

Embryonic mesoderm is formed from mesoderm found at very early

stage between the two inner sacs of zygote (or that is replaced by mesoderm derived from proliferation of cells of the primitive streak). In embryonic area, mesoderm is absent in median plane where notochord is formed (unless notochord is regarded as mesodermal in origin), and it is absent, in front of notochord, from a small area which afterwards becomes *bucco-pharyngeal membrane*.

Mesoderm along anterior end of embryonic area, just in front of bucco-pharyngeal membrane, afterwards forms mesodermal wall of pericardial cavity, and is called **pericardial mesoderm**.

Since the cephalic fold is formed as a fold drawn forwards over and beyond the margin of the embryonic area, it follows that its ventral wall is formed from the more anterior part of the area involved in the fold, and that the surface of the ventral wall which now looks dorsally into the cavity of the fore-gut looked originally ventrally into the cavity of the entodermal sac, while the present posterior end of ventral wall lay in the ant. part of embryonic area, in front of the region now forming ant. part of fold. Pericardial mesoderm, which lies in anterior extremity of the area, is also overturned; its surfaces and borders are reversed by the folding; and the bucco-pharyngeal area, at first posterior to it, is now anterior to it.

Mesoderm in embryonic area is at first a single layer. Its *medial part* becomes thickened, along each side of neural groove and tube, to form longitudinal bars, called **paraxial mesoderm**. A cleft, called the **embryonic coelom**, appears in its *lateral part* and extends out to become continuous with extra-embryonic coelom, and it divides the lateral part into a dorsal or somatic layer, and a ventral or splanchnic layer, continuous with corresponding layers of extra-embryonic mesoderm.

The **somatic layer** lines the embryonic ectoderm, and from it are formed: (1) parietal pleura, pericardium and peritoneum, (2) ventro-lateral walls of body, and (3) the limbs.

Splanchnic layer covers primitive alimentary canal, and from it are formed visceral pleura, pericardium and peritoneum, connective tissues and muscles of alimentary canal, spleen, heart and great blood-vessels. Muscles of mastication and facial muscles are said to be formed from lateral parts in head region.

Between the lateral embryonic mesoderm and the paraxial mesoderm there is, on each side, a thin incleft streak of mesoderm—the **intermediate cell area**. It is the rudiment of genito-urinary system. It separates from the paraxial mesoderm; enlarges to form an elongated body, called **Wolffian body** or primitive kidney, lying in dorsal angle of coelom. Wolffian duct and tubules and Müllerian duct are developed in connection with it. After 2nd fetal month the Wolffian body degenerates and is replaced by permanent kidney, which is formed in same mesodermal strand, dorsal to caudal end of W. body.

Except in head region, the paraxial bars of mesoderm are cleft into cubical masses, called **proto-vertebral somites**.

Medial cells of somites of each side proliferate, migrate medially, surround notochord and neural tube in continuous sheath, called **membranous vertebral column**, from which are developed vertebrae and their ligaments, greater part of intervertebral fibrocartilages, membranes of brain and medulla spinalis (spinal cord). Other parts of somites form vertebral muscles and subcutaneous tissues of back, and probably of limbs and body wall. Head part of paraxial mesoderm forms muscles of eyeball and tongue, and muscles connecting head to shoulder girdle.

Surface ectoderm of embryo forms epithelium of skin; sweat, sebaceous, mammary and lacrimal glands; conjunctiva; hair and hair follicles; nails and adamantine (enamel) of teeth; epithelium and glands of roof of mouth, inner surfaces of cheeks, nasal cavities and sinuses arising from them, and ant. lobe of hypophysis (pituitary body); epithelium of parotid gland and lower part of anal canal, epithelium of external acoustic meatus, and outer layer of tympanic membrane; auditory and olfactory epithelial elements and those of lens and cornea.

Neural ectoderm gives rise to cells, fibres and neuroglia of nervous system, central and peripheral; epithelium of retina, post. lobe of hypophysis, pineal body.

Entoderm gives rise to epithelium of alimentary canal, except part of mouth external to inner gum and terminal part of anal canal; also to epithelium of auditory (Eustachian) tube, tympanic cavity, trachea, bronchi, vesicles of lung; taste buds of tongue, submaxillary and sublingual glands, liver, gall-bladder, pancreas, and all other glands which open inside teeth; vesicles of thyroid gland, cell nests of thymus, urinary bladder, part of urethra.

APPENDAGES OF EMBRYO AND FŒTUS

Amnion, Chorion, Umbilical Vesicle, Allantois

The embryo is enclosed in two membranes, the **amnion** and the **chorion**. The chorion consists of trophoblast and its mesodermal lining. It is greatly thickened and specialised in the region where it first becomes adherent to uterine mucous membrane, which also is thickened in that region; and from these thickenings the **placenta** is formed. The embryo is connected with the placenta by the **umbilical cord**. All these, except the maternal portion of the placenta, are formed from the fertilised ovum.

The ovum is fertilised probably in upper part of uterine (Fallopian) tube; enters uterus either in morula or early blastula stage, and at once becomes imbedded in uterine mucous membrane.

Mucous membrane of uterus is greatly increased in thickness and vascularity in order to receive ovum, and is then called **decidua**.

Ovum is implanted near fundus of uterus posteriorly, and eats its way into decidua. The part of decidua between ovum and muscular wall of uterus is called **decidua basalis**; that which covers ovum is called **d. capsularis**. Remainder is called **d. vera**. Decidua increases further in thickness and vascularity, and is divisible into 3 layers: (1) *stratum compactum* superficially, where interglandular tissue predominates; (2) *stratum spongiosum*, formed by dilated portions of glands; (3) *unchanged layer* of bases of glands, next muscular wall of uterus.

Decidua capsularis consists of part of stratum compactum only, and with enlargement of ovum it is pushed before ovum till it meets d. vera, obliterating uterine cavity, about end of 3rd month. The fused decidua capsularis and vera atrophy, and are reduced to thin membranes.

D. basalis consists of unchanged layer, spongy layer and external part of compact layer, which form maternal part of placenta. The vessels in the part of compact layer next ovum dilate enormously to form large blood sinuses. External part of compact layer remains unchanged, is called *basal layer*, and is perforated by uterine vessels which dilate to form the sinuses.

Earliest observed stage of human ovum is that showing the space between trophoblast and inner two sacs filled with mesoderm which surrounds the inner two sacs and passes in between them into embryonic area.

Extra-embryonic cœlom, which appears in the mesoderm and divides it into 2 layers, extends into the mesoderm between the trophoblast and dorsal surface of amnion, but leaves the caudal ends of amnion and entodermal sacs attached, by a mesodermal stalk, to that part of trophoblast which lies opposite decidua basalis and becomes fetal portion of placenta.

A diverticulum, called the **allantois**, grows into mesodermal stalk from that part of entodermal sac which later becomes included in the caudal fold as the hind gut. Blood-vessels pass along allantois from embryo to placenta. Part of allantois taken into embryo with formation of hind-gut becomes adult urachus. (It is also said that no part of allantois is taken into embryo, but that it is connected with hind-gut at umbilical margin, and that urachus is formed, therefore, from cloaca.) When caudal fold is formed, the part of the embryo with which mesodermal stalk is connected is the ventral wall of body, at caudal margin of umbilicus.

The **umbilical vesicle** is that part of entodermal sac left outside the embryo. It retains its connection with primitive alimentary canal, at umbilicus, by a neck which becomes narrow and constricted, and is called **vitello-intestinal duct**. The duct becomes elongated and mesoderm covering it fuses with cephalic aspect of mesodermal stalk, which also has become elongated.

Amnion is the upper or dorsal of the two sacs formed from inner cell mass. It is covered with mesoderm. When embryo is formed by folding, and projects up into its cavity, it is connected: (1) with embryo, around umbilical orifice, and (2) with trophoblast, by mesodermal stalk. Otherwise its mesoderm and that lining trophoblast are separated by the space called *extra-embryonic cœlom*. **Amniotic fluid** accumulates in amniotic sac and distends it in all directions, until the extra-embryonic cœlom is obliterated by fusion of mesoderm covering amnion (1) with mesoderm lining trophoblast; (2) with that covering umbilical vesicle; and (3) with that forming mesodermal stalk, which it surrounds on all sides.

Umbilical cord includes the mesodermal allantoic stalk and diverticulum, umbilical vessels, atrophied vitello-intestinal duct—all ensheathed in covering of amnion. At birth it is a spirally twisted cord, 20 in. long, connecting umbilicus of fœtus to placenta, and containing *two* umbilical arteries and *one* vein. Its mesodermal tissue is represented by a mucoid substance, called **Wharton's jelly**, enclosed in amniotic sheath.

Chorion is composed of trophoblast and its mesodermal lining. When ovum is imbedded in uterus, processes called villi grow from chorion into surrounding deciduæ. Villi which grow into d. basalis persist; the rest disappear. Villi at first consist of trophoblast only, but, later, acquire vascular cores of mesoderm. Chorion becomes very thick in the region where it forms placenta, *i.e.* in region of decidua basalis, where also the mesodermal stalk is connected with trophoblast. There its villi are very large and branching. They project into the maternal blood sinuses in compact layer of d. basalis, and also into tissue between the sinuses, consuming and replacing not only that tissue but also the endothelium of the sinuses, so that villi not only project into blood spaces, but also form their walls, except at points where vessels pierce basal layer to open into blood spaces; villi are therefore bathed on all sides in maternal blood occupying the spaces; and villi make up the bulk of the placenta.

Placenta is the fœtal nutritive, respiratory and excretory organ, interchange of material taking place, through walls of villi, between maternal blood in blood spaces and fœtal blood which is conveyed to and from placenta by umbilical vessels and circulates in capillaries in villi. Its formation is complete at end of 3rd month. It contains trophoblast and mesoderm of chorion, umbilical blood-vessels, and decidua basalis; remains of umbilical vesicle lie under amniotic covering of placenta. At birth, it is a disc, 20-25 inches in circumference, 1½ inches thick at centre, about 1 lb. in weight. Covered on fœtal surface by smooth amnion, and connected with umbilical cord usually near centre. Uterine surface is rough and lobulated.

Expulsion of Embryo from Uterus.—When intra-uterine life is complete the uterus contracts, its lower orifice dilates, amnion and

chorion are ruptured, *liquor amnii* (or amniotic fluid) and foetus are expelled, and umbilical cord is cut artificially and tied.

Further contraction of uterus separates placenta and membranes from uterine wall, through plane of spongy layer of decidua, and they are expelled, the membranes being inverted, so that amnion is outermost.

The membranes consist of fused amnion and chorion, and shreds representing compact layers of fused decidua vera and d. capsularis.

Uterine vessels to placenta are torn and some blood escapes, but bleeding to any extent is prevented by continued contraction of uterus. If uterus relaxes after separation of placenta **post-partum hæmorrhage** results.

The mucous membrane is reconstructed from "unchanged layer" of decidua.

DEVELOPMENT OF NOSE AND MOUTH

Anterior part of cephalic fold projects ventrally and is called **fronto-nasal process**. Pericardial mesoderm bulges forwards. Depression between them is called **stomodæum**. Thickenings, called arches, appear in each lateral wall of fore-gut. First of these is called **mandibular arch**. Its ventral end grows till it meets its fellow, anterior to pericardial bulging. A process, called **maxillary process**, projects anteriorly, from dorsal end of mandibular arch, towards fronto-nasal process. Stomodæum is bounded: (1) *cranially* by fronto-nasal process; (2) *caudally* by pericardial bulging, and later by mandibular arches; (3) *laterally*, on each side, by mandibular arch and its maxillary process; (4) its *dorsal wall* is bucco-pharyngeal membrane, which disappears during 3rd week, and then stomodæum communicates with fore-gut. Stomodæum develops into *nasal cavities* and *upper part of mouth*.

Two depressions, called **olfactory pits**, appear on free projecting margin of fronto-nasal process. Ectoderm lining them becomes olfactory epithelium of nose and part of olfactory bulb. Pits deepen and grow backwards along roof of stomodæum, dividing fronto-nasal process into a median and two lateral nasal processes. Free angles of **median nasal process** become rounded and projecting, and are called **globular processes**. Intermediate region of median nasal process is divided by transverse ridge into upper triangular area, which becomes dorsum of nose, and lower quadrilateral area, which becomes free part of septum of nose. Globular processes come together and fuse to form the *philtrum*, *i.e.* the median part of upper lip. **Lateral nasal processes** become alæ of nose.

Maxillary process grows medially, below eye, to form lateral wall and floor of orbit, lower lateral wall of nasal cavity, cheek and lateral part of upper lip; fuses with globular and lateral nasal processes. Stomo-

caudal orifice is thus divided into two nostrils and a large oral orifice. **Oculo-nasal sulcus**, which, for a time, separates maxillary and lateral nasal processes, becomes walls of lacrimal sac and naso-lacrimal duct.

A ridge, called **nasal lamina**, grows backwards for a short distance along roof of stomodæum from each globular process. They fuse and form premaxillary or incisive portions of maxillæ. Posterior to these, a horizontal ledge grows medially from inner surface of each maxillary process; the ledges fuse with one another in median plane, and with nasal lamina anteriorly, and form *palate*. At the same time a median septum grows down from under surface of median nasal process and fuses with palate. It contains a core of cartilage continuous with cartilage of base of skull. This is replaced posteriorly by *vomer* and *perpendicular part of ethmoid*, and becomes *septal cartilage* anteriorly. Nasal and oral cavities are now separated, and the nasal cavities are separated from one another. A process from cartilage of cranial base projects into upper lateral part of nasal cavity and becomes labyrinth of ethmoid and inferior concha (turbinated).

Hare-lip results from non-union of maxillary and globular processes. *Cleft palate*, from non-union of palatine process with nasal lamina and with its fellow.

PARTS DERIVED FROM PRIMITIVE ALIMENTARY CANAL.

Tuberculum Impar and Furcula.—Two elevations appear in floor of fore-gut: an anterior, rounded, called **tuberculum impar**, becomes the central and posterior area of ant. $\frac{2}{3}$ of tongue. The posterior, called **furcula**, a ridge bent like a hair-pin, encloses a median groove and is bounded by a groove called **sinus arcuatus**. Upper, closed end of furcula forms *epiglottis* and *ary-epiglottic folds*. Lips of median groove meet and fuse, converting groove into a tube which becomes detached from the part of floor of fore-gut which forms œsophagus, but retains communication, by its upper end, with part that becomes pharynx. The tube becomes cavity of *larynx* and *trachea*. Its lower end bifurcates to form rudiments of *bronchi*, before lips close to form tube. End of each bronchus enlarges to form vesicles of *lungs*. Left divides into 2, right into 3, forming lobes of lung; and each invaginates its own side of pleural part of colon.

Visceral Arches, Clefts and Pouches.—On each side, in lateral wall of that part of fore-gut which becomes pharynx, localised thickenings of mesoderm produce 5 bars, called **visceral arches**, seen best from inside. The 1st is largest and most anterior. They diminish in size serially, so that 5th is smallest and is seen only from inside. The arches are separated on the inside by grooves called **visceral pouches**, and on outside by grooves called **visceral clefts**. In these grooves, between the arches, the surface ectoderm and the entoderm are separated by little or no mesoderm.

Entoderm of 1st pouch becomes mucous membrane of *auditory tube* and *tympanic cavity and antrum*. Ectoderm of 1st cleft becomes skin of *ext. meatus*. Both contribute to *tympanic membrane*. Ectoderm and entoderm of 2nd, 3rd, 4th clefts and pouches assist in forming skin of neck and mucous membrane of pharynx, respectively; and the following also are formed of the entoderm:—*Pharyngeal recess* may arise from upper part of 2nd pouch, *supra-tonsillar fossa* from lower part, palate having grown backwards between them. *Crypts of palatine tonsil* are formed from 2nd pouch by 8 to 10 entodermal buds, which grow into wall of pharynx and become surrounded by mesodermal lymphoid tissue of tonsil. *Thymus* is derived from two buds which grow from entoderm of 3rd pouch. Stalks of buds disappear. Space in front of and at sides of epiglottis is a remnant of 3rd pouch. *Parathyroids* arise partly from 3rd, partly from 4th pouch of each side.

Thyroid Gland.—A median entodermal bud grows downwards, in front of hyoid bone and larynx, from groove behind tuberculum impar, and bifurcates to form isthmus and lateral lobes of thyroid gland. Stem forms *thyreo-glossal duct*, whose upper end remains as *foramen cæcum* of tongue, while lower end forms *pyramid of thyroid*, and intermediate part becomes fibrous cord, broken up by hyoid bone. Duct may partly persist and form cysts above and below hyoid bone.

Piriform recess at side of larynx is a remnant of 4th pouch.

1st arch is called mandibular; 2nd, hyoid; 3rd, thyreo-hyoid; 4th and 5th, unnamed. Each consists of ectoderm and entoderm enclosing a mesodermal core, in which are developed a *bar of cartilage*, a *nerve*, and an *arterial cephalic aortic arch* (which is dealt with under Vascular System, p. 508). Dorsally, the visceral arches end at side of head, below level of neural tube; ventrally, in early stage, they rest on pericardium; but as head grows they are carried beyond pericardium and lie in ventral wall of neck.

1st arch forms lateral and lower boundaries of stomodæum. It meets its fellow in front of tuberculum impar. It forms soft tissues around mandible, and forms anterior and lateral parts of ant. $\frac{2}{3}$ of tongue, and the teeth of mandible. Its cartilage is called **Meckel's cartilage**. Ventral end of cartilage becomes included in the part of *mandible* medial to mental foramen. Dorsal end ossifies to form *malleus* and *incus*. Remainder disappears, but membrane covering it forms *spheno-mandibular lig.* Nerve is *mandibular*. **Maxillary process** grows from anterior border of dorsal end of arch to form lateral part of upper lip, and face between orbit and mouth; and contains a process of cartilage, in association with which the *maxilla*, *zygomatic* (malar), *palatine* bones and *medial pterygoid lamina* are developed.

The other arches form sides and front of neck. Ventral end of 2nd arch insinuates itself between tuberculum impar and furcula, and fuses with fellow of opposite side to form *post. $\frac{1}{4}$ of tongue*. Tongue is formed, therefore, from mandibular and hyoid arches and tuberculum

impar. *Sulcus terminalis* of adult tongue indicates division between part formed by hyoid arch and that formed by tuberculum impar and first arch. Cartilage of 2nd arch is replaced by *styloid process*, *stylohyoid lig.*, *lesser horn* and *medial part of body of hyoid*. Nerve of 2nd becomes *facial*. Ventral end of cartilage of 3rd persists to form *greater horn* and *lateral part of body of hyoid*; rest disappears. Nerve is *glosso-pharyngeal*. Ventral ends of cartilages of 4th and 5th form *cartilages of larynx*. Nerves are *superior laryngeal* and *recurrent*.

The Cervical or Precervical Sinus.—As growth proceeds, 3rd and 4th arches are overlapped by 2nd, and cleft between overlapping 2nd and submerged 3rd and 4th is called the precervical sinus.

Platysma is an extension of musculature of 2nd arch.

Œsophagus—Stomach—Duodenum

Groove of furcula becomes a tube and is separated off to form cavity of larynx and trachea. Part of fore-gut from which it is separated becomes *œsophagus*, which is elongated by downgrowth of stomach.

Stomach appears, about 4th week, as a fusiform dilatation of fore-gut, caudal to furcula, in region of heart. It descends into abdomen as diaphragm is formed. Dorsal surface grows more rapidly—hence the *greater curvature*. It is rotated so that left surface becomes ventral, and therefore the left vagus is found on antero-superior surface, in adult. Greater curvature continues to grow, and in a direction to the left and caudally.

Mesentery of stomach, or *dorsal mesogastrium*, is originally attached at median plane, and its surfaces are right and left. Owing to rotation of stomach and continued growth of greater curvature, the right surface of mesogastrium comes to look ventrally, and the left, dorsally. Part of dorsal surface fuses with parietal peritoneum, so that line of attachment is to left of median plane above, and curves medially to reach median plane below.

Duodenum also rotates. Its mesentery fuses with parietal peritoneum and right side of duodenal loop becomes adherent to dorsal wall of abdomen.

Rudiment of *omental bursa* (lesser sac) is produced by (1) rotation of stomach, (2) shifting of attachment of mesogastrium to the left, and (3) fixation of duodenum. Portion of mesogastrium connected with lower, right part of greater curvature protrudes caudally to form *greater omentum*.

Spleen—Liver—Pancreas

Spleen develops from mesoderm between layers of upper, left part of mesogastrium, and divides it into *gastro-splenic* and *lienorenal ligaments*.

Liver.—A diverticulum grows out from ventral wall of duodenum. It becomes separated into a hepatic section, which forms hepatic duct and its branches and main mass of glandular substance of liver, and a 2nd segment, which forms gall bladder with its duct, and bile duct.

Hepatic rudiment grows into a mesodermal mass, called septum transversum, which becomes part of pericardium and diaphragm and provides mesodermal elements of liver. Rudiment enlarges and forms right and left lobes of liver. Liver grows out of septum again into abdominal cavity, dragging with it mesodermal tissue, called *ventral mesogastrium*, which becomes thinned down to form *falciform ligament* and *lesser omentum*. Liver grows completely out of septum, but is retained in contact by mesodermal tissue, which becomes *coronary* and *right and left triangular* (lateral) *ligaments*.

In early months the liver almost fills abdominal cavity. Growth is relatively less rapid in later months, but even at birth it is $\frac{1}{8}$ of body weight and fills half the cavity, and left lobe touches spleen and left kidney. In adult it is about $\frac{1}{8}$ of body weight, left lobe having been reduced relatively more than right.

Pancreas.—There are originally 3 pancreatic rudiments, a dorsal and 2 ventral. They arise from duodenal part of fore-gut and the left ventral soon disappears. The **dorsal rudiment** forms *body* and *tail* of pancreas. The persisting **ventral rudiment** arises in connection with bile duct, and forms *head* of pancreas. The rudiments fuse; and a communication between their ducts enlarges so that the contents of duct of dorsal part is deflected into ventral duct, and terminal part of dorsal duct remains small. Body and tail, derived from dorsal diverticulum, grow into dorsal mesogastrium, the body lying in that part which fuses with parietal peritoneum, the tail in part which becomes heno-renal ligament.

Intestine

Intestine is derived from mid- and hind-guts, and is held to dorsal wall of abdomen by a mesentery. The part that comes to form *jejunum*, *ileum*, *ascending* and *transverse colon* projects ventrally as a loop, which partly descends into umbilical cord and encloses a prolongation of the mesentery which contains sup. mesenteric art. between its layers. Vitello-intestinal duct is attached to apex of loop; it persists in 2 per cent. of cases as *Meckel's diverticulum*, situated about 3 feet from end of ileum.

Cæcum appears as small outgrowth on caudal side of duct. Ends of loop come close together, and loop is rotated around mesenteric artery as an axis, so that left side of its contained mesentery becomes right side, and caudal, coile part crosses ventral to duodenum, and, after loop is drawn back into abdomen, the caecal protrusion lies on right side of abdomen, below liver. Cæcum descends to iliac fossa

about sixth month. The apical part of cæcum grows in length, but its lumen remains small; and it becomes *vermiform process*. Downward enlargement of antero-lateral wall of cæcum, from region above base of vermiform, brings vermiform to its adult postero-medial position, above blind end of cæcum. Mesentery may all persist, but the part in connection with descending colon usually fuses with parietal peritoneum. Transverse mesocolon fuses with posterior layers of greater omentum. Ascending colon is produced as the cæcum grows downwards from liver; it has no mesentery but may acquire one. Mesentery proper assumes its oblique attachment as cæcum grows downwards.

Cloaca.—Part of hind-gut posterior to its connection with allantois is called cloaca. From the point where dorsal surface of allantois is joined to ventral surface of hind-gut a septum grows caudally, partially dividing cloaca into *rectum* dorsally and genito-urinary part ventrally. The caudal wall of cloaca is formed by the caudal part of the primitive streak region which was bent ventrally as tail fold formed. It now forms a membranous septum between cloaca and amniotic cavity, and is called cloacal membrane. The membrane consists of ectoderm and endoderm only. By growth of surrounding parts the membrane comes to form floor of a depression called *cloacal fossa*. Mesoderm grows into membrane from sides, and forms a transverse ridge dividing fossa into *proctodæum* dorsally and urogenital fossa ventrally. Septum described above fuses with this ridge and completely separates rectum from urogenital part. The sphincters are formed in walls of proctodæum and it becomes lower part of *anal canal*. The part of the cloacal membrane in floor of proctodæum, separating proctodæum from rectum, disappears about 3rd month. Anal valves may be remnants of this membrane.

Post-anal or *tail-gut* is a diverticulum of hind-gut under root of tail. It usually disappears, but may persist and give rise to tumours.

GENITO-URINARY ORGANS

Cloacal membrane between cloacal fossa and genito-urinary part of cloaca disappears at early period. At ventral end of urogenital fossa there is a *genital eminence*, grooved on caudal surface. In male, the eminence forms *penis*; the lips of groove come together and enclose canal of cavernous part of urethra. In female, the eminence forms *clitoris*; lips of groove come together but enclose no canal. Glans part of urethra appears first as solid cord of epithelium, which becomes channelled and connected with canal in body of penis. Margins of urogenital fossa come together and form *raphe* of scrotum and penis in male. In female it remains unclosed as **genital cleft**.

Ventral part of cloaca consists of *cephalic vesical part*, and *uro-genital canal* caudally. Floor of urogenital fossa disappears and canal opens into it. Vesical portion, **in male**, forms *bladder* and upper

part of *prostatic urethra*. Urogenital canal forms *membranous urethra* and rest of *prostatic urethra*. In female, vesical portion forms *bladder* and *whole urethra*; urogenital canal becomes shorter and shorter till it merely surrounds opening of urethra and vagina into genital cleft.

It is said that vesical part forms *urachus* also.

Wolffian duct appears as solid rod of mesoderm cells on dorsal aspect of intermediate cell mass, towards cephalic end of body. As it grows caudally it becomes for a time connected with ectoderm, becomes soon separated, sinks into substance of increasing cell mass. It soon gets a lumen, and caudal end turns ventrally and opens into urogenital canal.

Wolffian body or **mesonephros** arises from intermediate cell mass. Consists of tortuous tubules, one end blind, other opening into duct. In male, the duct becomes *duct of epididymis*, *ductus deferens* and *ejaculatorius*. *Seminal vesicle* is a diverticulum from it. In female, duct partly persists as longitudinal tubule of ep- and par-oophoron and appendices vesiculosi. Wolffian tubules nearly all disappear, but in male they form *rete testis*, *ductuli efferentes*, *lobuli epididymidis*, and *paradidymis*. In female, they form transverse tubules of par-oophoron and ep-oophoron.

Ureter arises as diverticulum from caudal end of Wolffian duct. Blind end dilates to form *pelvis renalis* and divides into branches to form *calyces* and *collecting tubules*. Rest of kidney tubules are formed from metanephric tubules, which correspond to Wolffian, but are situated more caudally. Ureter separates from W. duct and gains independent opening into bladder-section of genito-urinary sinus, nearer cephalic end.

Testis and Ovary On medial side of Wolffian body a mesodermal ridge appears, known as *germinal ridge*. It is covered by a layer of germinal epithelium, which consists of modified peritoneal epithelium, intermingled with germinal cells, which are progenitors of ova or spermatozoa. Ova and ovarian follicles, spermatozoa and contorted seminiferous tubules are developed from it. The underlying mesoderm forms stroma of ovary or testis; outgrowths of Wolffian body form excretory tubules of testis. The genital gland becomes isolated and slung by short mesentery. A band of mesoderm is found extending from skin which later becomes *libium majus* or *scrotum*, through tissues of lower part of ant. abdominal wall, along dorsal wall of abdomen, to diaphragm. Lower part is called **gubernaculum**, and becomes adherent to genital gland and peritoneum on its caudal side. In male it does not grow *pari passu* with body, but probably shortens. Peritoneum caudal to testis is narrowed to form a tube, and is drawn down through ant. abdominal wall to *scrotum*; or ant. abd. wall is formed on such a plane that tube is excluded from abdominal cavity. The tube is called *processus vaginalis*. Testis is drawn down behind it and invaginates its lower part, which becomes *tunica vaginalis testis*. Upper part usually shrivels.

In female, ovary is dragged down to brim of pelvis, where gubernaculum becomes adherent to uterus. Uterus sinks into pelvis, dragging gubernaculum and ovary with it. Gubernaculum becomes round ligament and lig. of ovary; and its length keeps pace with growth of adjacent organs.

Descent of testis and ovary through abd. cavity may be owing to growth at lower end and atrophy at upper end.

Müllerian ducts are formed, one on each side, on lateral side of Wolffian body, by tubular invagination of mesoderm lining body cavity. Their cephalic ends open into body cavity. They grow caudally, cross Wolffian ducts, unite to form single tube which opens into urogenital canal. Fused portions become *uterus* and *vagina*. Owing to shortening of urogenital canal, the vagina comes to open directly into urogenital cleft. Unfused portions become *uterine tubes*, which, in adult, still open into body cavity.

In male, the Müllerian ducts partly persist as *prostatic utricle* and *appendices testis*.

Glands of prostate, bulbo-urethral and vestibular glands arise as outgrowths from urogenital canal.

VASCULAR SYSTEM

First appearance of blood-vessels is on yolk sac, where channels run together to form **vitelline veins**. About same time, just when folding off of embryo is beginning, two **primitive aortæ** appear in ventral or splanchnic layer of pericardial mesoderm. They extend cephalwards and caudalwards, and are carried on to yolk sac and join vitelline veins. At caudal end they give off large branches to be carried along allantois to chorion.

When cephalic fold is formed the **pericardium** is carried round and lies below fore-gut, with surfaces reversed, the splanchnic layer having become dorsal in position. Its cavity is continuous on each side with pleuro-peritoneal cavity, but continuity is soon obliterated. Caudal border thickens to form a semilunar mass called **septum transversum**, which becomes *diaphragm*. In median plane, the septum grows dorsally towards fore-gut. Laterally, it sends out falseiform prolongations between lining of coelom and rest of body wall. These grow medially towards fore-gut, dividing coelom into *peritoneal* and *pleural cavities*.

Primitive aortæ are carried round with pericardium, and each then consists of three parts: (1) *anterior ventral aorta*, on dorsal surface of pericardium, and continuous through septum transversum with vitelline vein; (2) *first aortic arch*, which lies in 1st visceral arch; (3) *primitive dorsal aorta*, ventral to proto-vertebral somites. When caudal fold is formed the umbilical branches of primitive aortæ pass through the fold on their way to placenta.

Each **ant. ventral aorta** is divisible into *anterior* and *posterior*

parts. Posterior part unites with its fellow to form *sinus venosus*, *primitive atrium* and *ventricle*, *bulbus cordis* and *truncus arteriosus*. Anterior part lies in root of neck. It is connected with dorsal aorta by 1st aortic arch, and, later, by 2nd and 3rd arches. 4th and 6th arches spring from truncus arteriosus and connect it with dorsal aorta. 5th springs from ventral root of 4th, and joins 6th.

Primitive dorsal aorta is divisible into *anterior* and *posterior* parts. Post. part fuses with fellow to form permanent *descending aorta*. Ant. part is connected with ventral aorta by the aortic arches. These, except the 5th, lie in the visceral arches of pharynx.

5th arch is rudimentary and may not appear. Nearly whole of 1st and 2nd arches of both sides and 6th of right side disappear. Primitive dorsal aorta, on right side, disappears, from 3rd arch back to point of fusion with left aorta: on left side it disappears between 3rd and 4th arches.

Adult *arch of aorta* is formed: (1) the part between beginning of arch and origin of innominate, from truncus arteriosus; (2) between innominate and left common carotid, from left ventral aorta; (3) remainder, from fourth arch and from anterior part of left primitive dorsal aorta. *Innominate and right common carotid and external carotid, left common and ext. carotid* are formed from right and left anterior aortæ; *internal carotids*, from 3rd arch and cephalic part of dorsal aorta; *right subclavian* from 4th arch; roots of right and left *pulmonary* from 6th arches; *ductus arteriosus* from left 6th arch.

Heart

The **heart**, a simple tube at first, is soon divided into 5 dilated portions—*sinus venosus*, *atrium*, *ventricle*, *bulbus cordis* and *truncus arteriosus*. Bulbus is absorbed, later, partly into ventricle, partly into truncus arteriosus. Heart elongates more than pericardium, and, therefore, becomes bent, the ventricle bulging caudally, the atrium mounting cephalwards on its dorsal aspect. At the same time **septa** begin to appear. Two thickenings, called *endocardial cushions*, appear in atrio-ventricular orifice or canal, approach one another and fuse, dividing orifice into two. *Ventricular septum* grows up from caudal end of ventricle and fuses with this bridge, and with septum of truncus arteriosus. *Septum of truncus* descends spirally and meets ventricular septum. It begins in truncus between openings of 4th and 6th pairs of arches and, therefore, only 6th pair communicate with right ventricle, all the others with left. Spiral grooves on surfaces of truncus, opposite septum, appear and deepen, and divide truncus into **ascending aorta** and **pulmonary trunk**. Spiral direction of septum accounts for relation of pulmonary trunk to aorta in adult; and as they both arise from the truncus they are ensheathed in one tube of serous pericardium.

Inside atrium an *atrial septum* grows caudally to meet endocardial cushions. Before fusion with cushions is complete, a foramen, called *foramen ovale*, appears in septum. A secondary septum grows down on right side of first septum. It fuses with first septum after birth and closes foramen ovale. Its caudal edge forms *limbus fossæ ovalis* (annulus ovalis).

Sinus venosus receives the veins. It lies dorsal and caudal to atria. Consists of large right horn, small left horn, and intermediate transverse piece. *Right horn* is gradually included in right atrium. In the adult the sulcus and crista terminalis, valve of vena cava (Eustachian) and valve of coronary sinus indicate line of union between sinus venosus and atrium. *Left horn* becomes lower part of oblique vein of left atrium (Marshall), rest of which is formed by left duct of Cuvier. *Transverse piece* becomes coronary sinus.

Veins

(1) Vitelline from yolk sac, umbilical from placenta, portal from abdominal viscera. (2) Primitive jugular, subcardinal and cardinal veins and ducts of Cuvier from head and neck, Wolffian body, trunk and limbs.

Vitelline veins come from yolk sac, pass through septum transversum, and enter sinus venosus. Liver grows into septum transversum and intercepts them, and their cardiac ends become the *hepatic veins*, which pass the blood on from liver to sinus venosus. Meantime, 3 transverse anastomoses unite distal parts of vitelline veins and form 2 contiguous circles, or figure of 8, around duodenum. Parts between liver and upper circle form right and left branches of portal vein, the left branch including also the proximal border of upper circle. Parts below circles disappear. Right part of upper circle and the part uniting the circles become portal vein; left part of lower circle is joined near upper end by superior mesenteric from intestines; other parts of circles disappear. Right hepatic vein is joined by the left, and part on cardiac side of union forms proximal end of inferior vena cava.

Umbilical veins outside abdomen fuse. Inside abdomen they pass inwards through septum transversum, open into sinus venosus, and afterwards in liver. Right vein disappears; left persists as *the umbilical vein* and opens into left branch of portal vein. A communication between right hepatic and left branch of portal enlarges to form *ductus venosus*; most placental blood then passes through it, but some goes into liver by left portal vein. Umbilical vein and ductus venosus persist till birth. After birth they shrivel and become lig. teres and lig. venosum, respectively.

Primitive jugular vein of each side returns blood from head, neck and upper limb. **Cardinal vein** of each side is dorsal to Wolffian body, and returns blood from body wall, Wolffian body, lower limb. Primi-

tive jugular unites with cardinal to form a **duct of Cuvier**, which opens into sinus venosus.

Left innominate vein is formed mainly from a cross branch between primitive jugulars. Transverse parts of *hemiazygos*, *accessory hemiazygos*, *left lumbar* and *left common iliac* are formed from cross anastomoses between cardinals. Primitive jugular on right side becomes *internal jugular*, *innominate* and upper $\frac{1}{2}$ of *vena cava superior*; on left side, *internal jugular*, the beginning of *innominate*, and upper part of *left superior intercostal*.

Ducts of Cuvier (sometimes called right and left superior vena cavae) become vertical by sinking down of heart from root of neck into thorax. Right becomes the part of *superior cava* inside pericardium; left becomes *fibrous cord* in vestigial fold of Marshall, and upper part of *oblique vein of left atrium* (Marshall).

Left cardinal vein, below entrance of renal vein, disappears except at caudal end, where it forms the *hypogastric* and beginning of *left common iliac*. Above renal vein it persists as *hemiazygos*, *accessory hemiazygos* and lower part of *superior intercostal*. **Right cardinal vein**, above renal vein, forms *v. azygos*; below renal, it becomes *inferior vena cava*, *right common ilia* and *hypogastric*.

Ventral to Wolffian bodies and parallel to cardinal veins are **2 subcardinal veins**. They are connected by anastomoses with one another and with cardinals. Most of these anastomoses disappear. Upper part of right subcardinal is joined by a downgrowth from right hepatic vein; this downgrowth forms the part of inf. v. cava which lies on back of liver; lower part of right subcardinal disappears.

Vena cava inferior is formed by (1) right hepatic vein, (2) downgrowth from right hepatic, (3) subcardinal, from liver down to level of renal, (4) anastomosis between subcardinal and cardinal, at level of renal; (5) cardinal, below level of renal. Cross channels between subcardinals at level of renal and between left subcardinal and cardinal form *left renal vein*. Lower part of left subcardinal disappears; upper part remains as *left suprarenal vein*.

Fœtal Circulation

Pure blood from placenta is carried by *umbilical vein* as far as liver, and then by *hepatic veins* and *ductus venosus* to *vena cava inferior* and thence to **right atrium**. Vena cava inferior conveys also impure blood from lower limbs and abdomen into right atrium. Therefore, blood carried by inf. cava to right atrium is not wholly pure, but is the purest there is to be distributed to the body of the fœtus. Valve of inferior cava (Eustachian) directs this blood into **left atrium** through foramen ovale; there it mixes with the small amount of

impure blood from lungs. From left atrium it passes to **left ventricle** and thence into the **aorta**, and nearly all passes into *innominate, left carotid* and *subclavian*.

Impure blood from head and neck, upper limbs and thorax is carried by **superior vena cava** to **right atrium**, from which it passes to **right ventricle** and is expelled through **pulmonary arterial trunk**. Lungs are functionless, and pulmonary arteries convey to them sufficient only for their nourishment; the greater part passes from pulmonary artery through *ductus arteriosus* to **aorta**, and mingles with some of the relatively pure blood in it. *Ductus arteriosus* joins **aorta** beyond origin of *subclavian* artery. Therefore head and neck and upper limbs receive purer blood than rest of body, and are relatively large at birth. Other parts of body are nourished by the less pure blood distributed by branches of the descending **aorta**; and a great part of the blood in **aorta** is sent by the umbilical branches of *hypogastric* arteries (*int. iliac*) to the placenta to be purified.

Changes after Birth.—Foramen ovale closes; *ductus arteriosus* becomes *lig. arteriosum*; *ductus venosus* becomes *lig. venosum*; umbilical artery becomes fibrous cord from pelvis to umbilicus; (*left*) umbilical vein becomes round *lig. of liver*. Pulmonary arteries enlarge greatly, in order to carry all the blood in the pulmonary trunk to the lungs.

NERVOUS SYSTEM

Neural tube is at first a single layer of ectoderm cells. These multiply and become differentiated into 2 sets. (1) **Spongioblasts** extend from central canal to surface. Their inner ends become columnar ciliated *ependyma* of central canal of spinal medulla and of ventricles of brain. Their outer parts become the *neuroglia* in substance and on surface of spinal medulla and brain. (2) **Neuroblasts**, which become *nerve cells and their processes*; they are aggregated in sides of tube, leaving its roof and floor plates free of neuroblasts.

Central canal becomes lozenge-shaped. The part of its lateral wall dorsal to its lateral angle is called *alar lamina*; ventral part is called *basal lamina*.

Medulla Spinalis.—In spinal medulla the *posterior column* of grey matter is developed in *alar lamina*, *ant. column* in *basal lamina*. In brain the *foveæ, superior* and *inferior*, and *sulcus hypothalamicus* (*Monro*) indicate line between *alar* and *basal laminæ*.

In spinal medulla the white matter is on outside of *laminæ*, and is

produced by growth of fibres arising in spinal medulla, and by fibres growing into it from spinal nerves and brain. As anterior columns grow and become covered with white fibres, each half of spinal medulla bulges ventrally, and anterior median fissure is formed between them. Dorsally no fissure is formed, and septum which separates post. columns consists of neuroglia. Up to 4th month spinal medulla extends whole length of vertebral canal. It extends only as far as sacrum at 6th month, to 3rd lumbar vertebra at birth, to lower border of 1st lumbar in adult.

Encephalon or Brain. Cephalic end of neural tube is dilated and divided by constrictions into **3 primary cerebral vesicles**, which develop into fore-, mid-, and hind-brains. Fore-brain and anterior part of head are bent round cephalic ends of foregut and notochord, so that a sharp *cephalic flexure* is formed in region of mesencephalon or mid-brain, which then forms the most prominent and bulging part of head in young embryos. Whole head is bent forwards so that a *cervical flexure* is produced at junction of hind-brain and spinal medulla. This is undone after birth, when head is raised. Brain tube is bent, without involving head, in region of pons, so that a forward convexity is produced, called *pontine flexure*.

Rhombencephalon or Hind-brain.—Its cavity becomes *4th ventricle* and canal of lower part of medulla oblongata. Lateral walls thicken, fall apart from one another, and form lateral halves of *medulla oblongata* and *pons*. Floor plate is thickened by fibres passing from one side to the other. Roof plate becomes greatly expanded. *Median part* of *cerebellum* and *medullary veli* are formed in it, but lower part remains ependymal only. *Lateral lobes* of *cerebellum* grow from alar laminae and appear before vermis. Cerebellar peduncles, that is, *brachia conjunctiva*, *brachia pontis*, and *restiform bodies*, are formed in alar laminae, in latter half of intra-uterine life, by fibres growing out of cerebellum and into cerebellum.

Before lateral walls of the part which forms medulla oblongata fall apart, their dorsal edges curl laterally, forming what is called the **rhombic lip**. This lip fuses with rest of alar lamina, covering in tractus solitarius and tractus spinalis (spinal root of V.), which lay at first on surface, and from rhombic lip are developed *olivary nucleus*, *nuclei of f. gracilis* and *f. cuneatus* and *nucleus of tractus spinalis* (subs. gel. Rolandi), and fibres arising from these nuclei.

Mesencephalon or Mid-brain.—Cavity becomes *cerebral aqueduct* (Sylvius). *Corpora quadrigemina* are developed in its dorsal surface from alar lamina, *tegmentum* and *cerebral peduncles* in its side walls. Floor is greatly thickened by intercrossing fibres.

Prosencephalon or Fore-brain.—Cavity becomes *3rd ventricle*. Floor is slightly thickened by intercrossing fibres. Roof remains as ependymal *roof of 3rd ventricle*. Anterior wall persists as *lamina terminalis*. Basal lamina becomes the parts grouped under term *hypothalamus*. Alar lamina develops into the parts grouped under

terms *thalamus*, *epithalamus*, *metathalamus*. From basal part there grow out two hollow protrusions which become *optic nerves* and *retinæ*. From alar parts, anteriorly, there grows a hollow bud which at once divides into two, to form *cerebral hemispheres*. Cavity in each becomes *lateral ventricle*. Communications with original cavity are retained as stem and limbs of *foramen interventriculare* (Monro).

Each hemisphere grows forwards, upwards, and backwards. It buries upper and lateral surfaces of thalamus and fuses with them. Part of hollow hemisphere covering upper surface of thalamus remains ependyma, and thalamus is seen through it, in floor of lateral ventricle of adult brain. Inferior horn is the original posterior end of lateral ventricle. The part of hemisphere enclosing it turns round thalamus and grows forwards as the temporal lobe; its medial wall remains ependyma, so that, in adult, an instrument can be passed into inferior horn through chorioidal fissure, after pia has been taken away, for invaginated ependymal wall is torn away with pia. Post. horn is a later diverticulum, and is wholly surrounded by fibres from corpus callosum.

Corpus striatum is developed as a thickening in floor and lateral wall of hemisphere. Fibres growing down from and up to cortex divide it into *caudate* and *lentiform nuclei*.

Optic chiasma is formed by fibres intercrossing in lower part of lamina terminalis. Upper part of lamina terminalis thickens. Lower part of thickening becomes partly isolated and fibres grow into it to form *ant. commissure*. Upper part grows upwards and backwards with hemispheres. Transverse fibres grow into its dorsal part to form *corpus callosum*. Longitudinal fibres connecting corpus mammillare and hippocampus grow into ventral part and form the *fornix*. The part of the thickening between corpus callosum and fornix becomes stretched to form *septum pellucidum*, and acquires a cavity. As thickening grows backwards and becomes invaded by corpus callosum and fornix it carries pia mater with it on both surfaces. Layer on inferior surface forms, with layer on roof of 3rd ventricle, the *tela chorioidea* of 3rd ventricle (*velum interpositum*). Chorioid plexus is formed in it and projects into lateral ventricle, pushing its ependymal medial wall before it. Inferior horn carries a prolongation of plexus with it.

Insula (Island of Reil) is the part of cortex in relation to corpus striatum, and is on surface of hemisphere up to 5th fetal month. Surrounding parts of cortex begin to grow more rapidly, and overlap the insula, so that it lies in a fossa—*fossa lateralis cerebri* (Vallecula Sylvii); and these overlapping parts finally cover insula and form the *opercula*. Opercula growing over insula from different points produce, and are kept apart by, the stem and branches of *fissura lateralis* (Sylvius).

Olfactory Apparatus.—Depressions called olfactory pits appear in roof of stomodæum, underneath fore-brain. A part of ectoderm of

pit is separated to form part of olfactory bulb. Rest forms olfactory epithelium of nose, and processes grow from its cells into olfactory bulb, and become *olfactory nerves*. A ridge appears on lower surface of cerebral hemisphere; there is a corresponding depression inside ventricle. Anterior part of this becomes separated as hollow outgrowth which solidifies and becomes *olfactory bulb, tract, area and trigone*. Posterior part becomes *ant. perforated substance* and *gyrus subcallosus*.

EYE AND INTERNAL EAR

Eye.—**Optic vesicles** grow out from lower and anterior part of fore-brain, from region occupied by adult *optic recess*. Vesicle becomes *retina*. Its stalk elongates and, acquiring nerve fibres coming from and going to retina, becomes solid and forms *optic nerve*. As development proceeds the fibres pass farther back and become connected with thalamus and mid-brain. Some cross and form *optic chiasma*, which is found only in highest primates, and is associated with binocular vision. Simultaneously with appearance of lens the infero-lateral aspect of vesicle and distal part of optic stalk become invaginated and form *optic cup*. The optic cup consists, therefore, of two layers. Inner becomes nervous and supporting layers of retina and pars ciliaris retinæ; outer becomes pigment layer. Pigment cells at back of iris are formed from both layers. Pathological separation of retina sometimes takes place between these two layers and fluid collects in original cavity of vesicle.

Vitreous is formed by modified cells of retina which correspond to neuroglia. Blood-vessels grow in between lens and retina, and carry with them a few mesodermal cells to the vitreous. Fissure produced by invagination of stalk closes up, so that *arteria centralis*, derived from these blood-vessels, occupies centre of optic nerve, and enters it on infero-lateral aspect, marking posterior limit of invagination.

Ectoderm overlying optic vesicle becomes thickened, invaginated, and cut off as a closed sac of a single layer, which forms the rudiment of the *lens*, and is separated from surface ectoderm by growth of mesoderm. It grows into the optic cup. Its posterior cells elongate and obliterate its cavity and form *lens fibres*. Anterior cells remain as *anterior epithelium of lens*. New lens fibres are added at margins by cells multiplying and elongating. *Capsule of lens* is formed by cells of lens, not from mesoderm. With age, the cells become changed into keratin, just as in skin. Oldest cells keratinise first. They are in centre; hence the central position of cataract.

Lens becomes enveloped in vascular tissue which, in man, disappears before birth. Ant. part of it is called *pupillary membrane*.

Condensed mesoderm around optic cup forms *clera, choroid, iris, ciliary body*. A cleft appears in mesoderm in front of lens. Cleft becomes *anterior chamber of eye*. Mesoderm behind it becomes

pupillary membrane. *Cornea* is formed from mesoderm in front of cleft, and from surface ectoderm. It becomes transparent.

Internal Ear.—Ectoderm above 1st visceral cleft, opposite hind-brain, becomes depressed, invaginated and cut off to form **otic vesicle**, which sinks into subjacent mesoderm, is met by outgrowing acoustic nerve, and develops into *membranous labyrinth*. Periotic cartilaginous capsule (p. 517) is developed in mesoderm around it.

VERTEBRAL COLUMN

Mesoderm of proto-vertebral somites grows medially, surrounds notochord and neural tube, and becomes condensed to form a **membranous vertebral column**. Vertebrae are formed in this, opposite intersegmental septa, *i.e.* opposite intervals between somites; hence each vertebra belongs to two somites. A "**membranous**" vertebra consists of *body* enclosed in a horse-shoe-shaped *vertebral bow*.

Chondrification begins about 4th week and a **cartilaginous vertebral column** is formed. Chondrification involves all parts except ventral part of bow, which, in most vertebrae, remains fibrous and fuses with intervertebral fibro-cartilage. In atlas, it forms anterior arch. Lateral parts of bow become vertebral arch and lateral parts of body. Transverse processes and spines grow out into intersegmental septa.

Ossification begins about 7th week in vertebral arches, about 10th week in bodies, and the **bony vertebral column** is formed.

Atlas vertebra is a completed vertebral bow. Body becomes dens (odontoid process); lateral mass represents the part of body of typical vertebra formed from vertebral bow. *Ligaments of odontoid process* represent fibro-cartilage between atlas and last occipital segment. Imperfect condition of *coccygeal vertebrae* is owing to failure of vertebral bow to chondrify and ossify. *Laminae of last 2 sacral* are incomplete, owing to imperfect chondrification and ossification.

RIBS AND STERNUM

Ribs are formed in intersegmental septa, and articulate at first with only one vertebra; but, later, the heads of all, except 1st, 10th, 11th, 12th, are shifted so that each articulates with fibro-cartilage and vertebra above as well. Ribs likewise pass through membranous and cartilaginous stages, before becoming bone.

Sternum is formed by condensation of mesoderm in front of pericardium producing two membranous sternal bars which fuse and chondrify to form 2 cartilaginous bars, and these fuse. Fibrous joints appear between segments; fibrous and, later, synovial joints are formed with costal cartilages, except in 1st, where, if synovial joint is formed, it soon disappears.

SKULL

Brain is surrounded by **membranous capsule** continuous with that surrounding medulla spinalis (spinal cord) and notochord. Chondrification begins in base, but ossification of membranous capsule begins in calvaria before chondrifying process has extended so far. Bones formed in membrane are *frontal, parietals, squamous temporals*, and *occipital above nuchal lines*. Centres appear for these about 7th week: 1 for each half of frontal, at frontal tuber (eminence), 1 for each parietal, at parietal tuber (eminence); 1 for squamo zygomatic, at base of zygoma; 1 for each half of occipital, near protuberance. Eminences of frontal and parietals are produced owing to greater convexity when bone is first formed—sphere of skull at the time having small radius. *Fonticuli* (Fontanelles) are unossified spaces at angles of parietal. They are closed by extension of bones around them. They are closed at birth, or shortly after, except the anterior, the largest, which closes at end of 2nd year. *Ossa suturarum* (Wormian bones) are formed by small ossific centres which sometimes appear in region of smaller fontanelles and help to close them. Sagittal fontanelle is an unossified space in region of parietal foramen. If it is unclosed at birth the parietal foramen will be large in the adult bone.

In base of skull, a **basal-cranial plate** of cartilage partly encloses notochord. Anteriorly, it forms *basal-occipital, post. part of body of sphenoid* and *dorsum sellae*. Posteriorly, it sends backwards an expansion on each side. These meet over hind-brain, enclose foramen magnum and form *lateral parts of occipital* and *squamous part of occipital below sup. nuchal line*. Fusion between them, behind foramen magnum, is not complete till shortly after birth. Space between them is *occipital fontanelle*. It is filled by extension of atlanto-occipital membrane. It is the commonest site for cerebral meningocele.

Periotic capsule is a mass of cartilage surrounding membranous labyrinth and int. carotid art. It forms *petro-mastoid* part of temporal, cartilage of *auditory* (Eustachian) *tube*, and cartilage which fills foramen lacerum.

Ethmoidal plate of cartilage lies in front of notochord. Posteriorly it joins basal-cranial plate. It forms *lamina cribrosa of ethmoid* and *anterior part of body of sphenoid*. It is cleft by *cranio-pharyngeal canal*, an opening through which a diverticulum from stomodæal ectoderm passes to form anterior lobe of hypophysis (pituitary body). A process from ethmoidal plate grows down into median nasal process. Part of that remains as *septal cartilage of nose*; part is ossified into *perpendicular lamina of ethmoid*; *vomere* arises in membrane surrounding posterior part. Processes grow out from plate, on each side, to form *great wing of sphenoid* and *lateral pterygoid lamina, small wing of sphenoid, labyrinth of ethmoid* and *lateral and alar cartilages of nose*.

Nasal and *lacrimal* bones, part of *frontal process of maxilla* are formed in membrane covering that part of the process of ethmoidal plate which forms cartilages of nose.

Zygomatic (malar) bone and arch, *maxilla*, *palatine* bone, and *medial pterygoid lamina* are formed from membrane covering cartilage in maxillary process.

Tympanic plate is developed in cartilage—origin doubtful.

Union of Bones of Skull, and Growth of Skull.—**Synchondroses** unite body of sphenoid with basi-occiput and with ethmoid, and jugular process with petrous temporal. These cartilages are ossified at 25th year. Other bones of skull are united by *sutures*.

As the skull bones grow at their edges, it is necessary that the sutures should be grouped in three planes: a horizontal, giving height; a vertical transverse, giving length; a vertical antero-posterior, giving breadth. Growth in thickness takes place under periosteum covering surfaces; growth in area of bone, and therefore of capacity of skull, takes place at sutures and synchondroses.

Metopic suture, between halves of frontal, is closed at 8th year, except at its lower end. Other sutures persist till after maturity. Principal sutures in adult are in connection with parietal bone: *sagittal*, between parietals; *coronal*, between parietals and frontal; *lambdoidal*, between parietals and occipital; *squamous*, between parietal and squamous temporal. They begin to be obliterated before middle age and are completely obliterated at advanced age.

Foramina in skull are in sutures between bones or between elements of which a bone is made up.

Growth of Face.—At birth the face forms only about *one-eighth* of size of head, owing to small size of jaws, nasal cavities and air sinuses. Increase takes place owing to development of temporary teeth and, still more, to development of permanent teeth; to enlargement of nasal cavities and air sinuses connected with them, especially maxillary sinus; till, at maturity, face forms *one-half* of the skull. Growth is greatly accelerated after 7th year.

LIMBS

Limbs grow out from sides of body, as buds, at end of 3rd week. Each corresponds to 7 segments. During 5th week, constrictions mark off *hand* and *foot*, and then *forearm* and *leg*. *Shoulder* and *hip* remain buried in body wall. *Digits* appear as ridges, separated by grooves, at 7th week. *Nails* begins to appear at 3rd month.

Extensor surface of limb looks laterally, flexor surface looks medially. Border looking towards head is called **pre-axial**, that looking tailwards is called **post-axial**. During 3rd month the limbs are rotated through 90°, in opposite directions, so that pre-axial border

of upper limb becomes lateral, and extensor surface dorsal ; pre-axial border of lower limb becomes medial, and extensor surface ventral. Limb girdles share in rotation.

Central mesoderm in each limb condenses to form a **membranous skeleton**, which chondrifies in 5th week—except where joints are to be formed—and a **cartilaginous skeleton** is produced. Ossification in large bones begins during 7th and 8th weeks.

Where a joint is formed, the periphery of the central condensed mesoderm becomes the *fibrous stratum* of the **articular capsule** ; central part, to a large extent, disappears and the *joint cavity* is formed ; but a part remains as the *synovial stratum* ; and sometimes part is retained as *interarticular discs* and *ligaments*.



INDEX

- Abdomen, 450
- Abdominal wall, 240
- Acetabulum, 66, **68**
- Acromion, 54
- Ala cinerea, 333
- Allantois, 495, 498, 499
- Alveus, 348
- Ammon, 498, 500
- Ampulla of Vater, 464
- Anastomosis, crucial, 295
- Angle, infrasternal, 29
- Ano-coccygeal body, **248**, 460
- Ansa** hypoglossi, 209, 398
 - lenticularis, 336
 - peduncularis, 336
 - subclavia, 215, 400
- Antrum** of Highmore. *See* Sinus, maxillary
- mastoid. *See* A., tympanic
- pyloric, 451
- tympanic, 39, 43, **412**, 503
- Anus, 459
- Aorta**, 262
 - abdominal, 263
 - branches of, 284
 - arch of, 262, **427**, 500
 - branches of, 264
 - ascending, 262, 500
 - branches of, 263
 - descending, 262, **431**, 508
 - branches of, 283, 431
 - primitive, 508
- Apertura** medialis ventriculi quarti, 332
- lateralis ventriculi quarti, 332
- Apertura** (*contd.*)—
 - piriformis, 38
- Aponeurosis**, epicranial. *See* Galea aponeurotica
- palatine, 202
- palmar, 139, **147**
- pharyngeal, 201
- plantar, 174, **181**
- vertebral, 191
- Appendices** epiploicæ, 458, 507
- vesiculosi, 487
- Appendix, vermiform. *See* Process, vermiform
- Aquæductus** cerebri, 334, 513
 - cochlear, 40, 415
 - vestibuli, 40, 414
- Arachnoidea, 359
- Arch, Arches**, aortic, 262, **427**, 500
 - branches of, 264
- carpal, volar, 154, 283
 - dorsal, 154, 281
- of foot, 123
- glosso-palatine, 441
- hyoid, 503
- humero-costal, 238
- mandibular, 501, 503
- pharyngo-palatine, 447
- plantar, **185**, 296
- pubic, 71
- superciliary, 36
- thyreo-hyoid, 503
- visceral, 502
- volar, **150**, **154**, 283
- zygomatic, 39, 43

Arcus parieto-occipitalis, 343

Area acustica, 333

bucco-pharyngeal, 497

of cardiac dulness, 257

cell, intermediate, 497

embryonic, 494

of Flechsig, 328

olfactory, 515

par-olfactoria, 346

Artery or Arteries, 262, 508

acromio - thoracic. *See* A.,
thoraco-acromial

alveolar, 270, 271

anonyma. *See* A., innominate

arcuate, 189

auricular, posterior, 230, 268

axillary, **130**, 278

basilar, 274

brachial, 280

bronchial, 284, 432

carotid, common, 27, 211, 216,

219, **264**, 265, 428, 509

external, 219, **265**, 445, 509

internal, 219, **271**, 509

carpal, 150, 154, 281, 282

centralis retinae, 272, 515

cerebral, 273, 275

cervical, deep, 213

circumflex, of axillary, **132**, 279

iliac, deep, 293

superficial, 168, 294

of profunda femoris, **169**, 294

scapular, **132**, 279

cœliac, 286

colic, 288

communicating, anterior, 273

posterior, 273

coronary, of face. *See* A., labial
of heart, 263

of stomach. *See* A., gastric

cremasteric. *See* A., spermatic,
external

dental. *See* A., alveolar

dorsalis clitoridis, 292

indici, 154, 281

linguae, 225, 267

nasi, 273

Artery or Arteries (*contd.*)--

pedis, 186, **189**, 297

penis, 292

pollicis, 154, 281

scapulae. *See* A., circumflex
scapular

epigastric, inferior (deep), 293

superficial, 168, 294

superior, 278

ethmoidal, 273

facial. *See* Maxillary, external

femoral, **168**, 293

frontal, 230

gastric, 286, 287

gastro-duodenal, 287

gastro-epiploic, 286, 287

genu, 169, **179**, 294

gluteal, 252, 290, 292

haemorrhoidal, inferior, 292

middle, 291

superior, 288

hepatic, 287

hypogastric, 289

ileo-colic, 288

iliac, common, 289

external, 292

internal. *See* A., hypogastric

ilio-lumbar, 290

infra-orbital, 271

innominate, 27, 211, 264, **428**,
509

intercostal, 278, 283, **431**

superior or suprema, 27, 213,
278

interosseous, anterior. *See*
A., volar, *below*

common, 282

dorsal (posterior), 283

volar, 282

lienalis. *See* A., splenic

lingual, 219, **225**, 267

lumbar, 284

mammary, internal, 27, 213, **277**

maxillary, external, 219, 224,
267

internal, 269

meningeal, middle, 269

Artery or Arteries (*contd.*)

- mesenteric, 287, 288
- musculo-phrenic, 278
- obturator, 291
 - abnormal, 291, 293
- occipital, 220, 230, 268
- ophthalmic, 272
- ovarian, 286
- palatine, 224, 266, 267, 271
- pancreatico-duodenal, 287
- pericardiaco-phrenic, 278
- perineal, 292
- peroneal, 295
- pharyngeal, 271
 - ascending, 220, 266
- phrenic, inferior, 284
 - superior, 283, 432
- plantar, 185, 296
- popliteal, 178, 294
- princeps polleis, 154, 281
- profunda cervicis, 213, 278
 - clitoridis, 292
 - femoris, 168, 294
 - linguae, 225, 267
 - penis, 292
- of pterygoid canal, 271
- pubental, external, 168, 294
 - internal, 252, 291
- pulmonary, 261, 509
- pyloric. *See* A., gastric (right)
- radial, 154, 281
- ranine. *See* A. profunda linguae
- renal, 285
- sacral, 285, 290
- scapular, posterior. *See* A., transverse cervical
- sciatic. *See* A., gluteal (inferior)
- sigmoid, 288
- spermatic, external, 293
 - internal, 285
- spheno-palatine, 271
- spinal, 322
- splenic, 286
- subclavian, 27, 204, 212, 216, 275, 276, 428, 509
- subcostal, 284, 432

Artery or Arteries (*contd.*)—

- sublingual, 225, 267
 - submental, 224, 267
 - subscapular, 132, 279
 - supra-orbital, 230, 272
 - supra-renal, 285
 - supra-scapular. *See* A., transverse scapular
 - sural, 179
 - temporal, superficial, 230, 269
 - thoracic, 132, 279
 - thoraco-acromial, 132, 278
 - thyreoid, inferior, 211, 277
 - superior, 210, 219, 266
 - thyreordea ima, 211, 264
 - tibial, anterior, 296
 - posterior, 295
 - tonsillar, 224, 267
 - transverse cervical, 205, 213, 277
 - scapular, 205, 213, 277
 - ulnar, 150, 281
 - collateral, 280
 - umbilical, 508
 - obliterated, 290
 - uterine, 291
 - vaginal, 291
 - vertebral, 212, 273
 - vesical, 290
 - Vidian. *See* A. of pterygoid canal
 - volar, superficial, 154, 281
- ARTICULATIONS**, 87. *See also*
- Joints
- Asterion, 38
 - Astragalus. *See* Talus
 - Atlas, 7, 17
 - Axilla, 130
 - Axis vertebra. *See* Epistropheus
- Band, ilio-tibial. *See* Tract
- Basis** cranii externa, 42
 - interna, 46
 - pedunculi, 334, 335
- Bladder, gall, 463, 505
 - urinary, 477, 506
- Blastula, 494

BLOOD VASCULAR SYSTEM, 253,
508

Bone or Bones

development of, 3
ossification of, 3
structure of, 2
sutural (Wormian), 517

Brachia conjunctiva, 331, 513

pontis, 329, 513
quadrigemina, 334

Brain, 323, 513

base of, 324

Bregma, 41

Bronchi, 422, 502

Buccæ. *See* Cheeks

Bulb, olfactory, 346, 515

of urethra, 485
of vestibule, 489

Bulbus cordis, 509

oculi, 404

Bulla ethmoidalis, 50

Bursa omentalis, 470, 504

Bursæ mucosæ, 125

Cæcum, 456, 505

Calamus scriptorius, 332

Calcaneus, 82, 86

Calcar avis, 345, 350

Canal or Canalis—

adductor, 164
Alecock's, 250
alimentary, 439
primitive, 494, 495
anal, 459, 502, 506
carotid, 46, 48
condyloid, 41, 44, 49
cranio-pharyngeal, 517
crural. *See* C., femoral
dental. *See* C., mandibular
facial, 389
femoral, 160, 167
of Huguier, 45
hyaloid, 407
hypoglossal, 44, 48
infra-orbital, 38
inguinal, 245
musculo-tubarius, 44, 45

Canal or Canalis (*contd.*)—

naso-lacimal, 38, 50
neurenteric, 495, 496
palatine, 40, 42
pharyngeal, 40, 42
pterygoid, 40, 42, 47
pterygo-palatine. *See* C., palatine
pyloric, 451
semicircular, 414
urogenital, 506
vertebral, 6
Vidian. *See* C., pterygoid

Capsule, external, of brain, 353

internal, of brain, 352

periotic, 517

of Tenon. *See* Fascia bulbi

Cardia, 451

Carpus, 60

Cartilage, costal, 24

ensiform. *See* Process, xiphoid

Meckel's, 503

semilunar. *See* Menisci

Cartilago triticea, 418

vomero-nasalis, 403

Caruncula sublingualis, 441

Carunculæ hymenales, 489

Cauda equina, 362

Cavity, amniotic, 494

peritoneal, 470, 508

proper of mouth, 440

thoracic, 423

Cavum tympani, 410

Cell mass, inner, 494

intermediate, 497

CENTRAL NERVOUS SYSTEM, 319

Centres, acoustic, 392

Cerebellum, 329, 513

Cerebral hemispheres, 338, 574

Chambers of eye, 407, 515

Cheeks, 440

Chest. *See* Thorax

Chiasma, optic, 335, 514, 515

Choanæ, 42

Chorda obliqua, 102

Chorioidea, 405, 515

Chorion, 498, 500

Ciliary body, 406, 515
 Cingulum of brain, 354
 Circulus arteriosus (Willis), 275
 Cisterna chyli, 312, 434
 Cisterns, subarachnoid, 359
 Claustrum, 352
 Clava, 325
 Clavicle, 51
 Cleft, genital, 506
 Clefts, visceral, 502
 Clitoris, 490, 506
 Cloaca, 506
 Coccyx, 15, 18
 Cochlea, 415
 Cœlon, 496, 497, 499, 500
 Colliculi, 334
 Colon, 456
 Columna vertebralis, 5, 15, 498, 516
Commissura anterior cerebri, 348, 514
 habenularum, 338
 hippocampi, 340
 posterior, 337
 Commissure of Gudden, 337
 Conchæ nasales, 32, 50
 splenoidales, 32, 50
 Condyle, occipital, 30, 44
 Confluens sinuum, 304
 Conjunctiva, 408
Conus arteriosus, 258
 elasticus, 419
 medullaris, 320
Cord, gangliated. *See* Trunk
 lumbo-sacral. *See* Trunk
 spermatie, 483
 spinal. *See* Medulla spinalis
 umbilical, 468, 500
 vocal. *See* Phœnx
 Cornea, 405, 516
 Corona radiata, 354
Corpus adiposum buccæ, 195, 440
 callosum, 347, 514
 cavernosum, 484
 dentatum. *See* Nucleus
 gemulatum, 333, 334, 337

Corpus (*contd.*)—
 mamillare, 336
 pineale, 337
 quadrigeminum, 333, 334, 513
 restiforme, 325, 327
 spongiosum. *See* C. cavernosum
 striatum, 352, 514
 trapezoideum, 392
 Corpuscles, Pacinian, 151
 Coxa. *See* Hip
Crest, frontal, 46, 49
 intra-temporal, 43
 neural, 490
 obturator, 68
 occipital, external, 41
 internal, 48
 palatine, 42
 supinator, 58
 supra-mastoid, 39
 Crista galli, 32, 40
 terminalis, 256, 510
 Crura cerebri. *See* Peduncles, cerebral
 Crusta. *See* Basis pedunculi
 Cuboid bone, 84, 86
 Cuneiform bones, 83, 86
 Cuneus, 345
 Cushions, endocardial, 509
 Decidua, 498
 Deglutition, 234
Diaphragm, 238, 508
 of mouth, 222
 pelvic, 248
 urogenital, 247
 Diaphragma sellæ, 358
 Differences between parts of an
 testis, 455, 458
 DIGESTIVE APPARATUS, 439
 Diploe, 2
 Diverticulum ilei, 455, 505
 Dorsum of foot, 188
 Dorsum sellæ, 47, 48
Duct, Ducts, Ductus—
 arteriosus, 509
 bile (choledochus), 463, 505

Duct, Ducts, Ductus (*contd.*)—

- cochlearis, 416
 - of Cuvier, 511
 - cystic, 463
 - deferens, 482, 507
 - ejaculatorius, 483, 507
 - excretorius, 483
 - hepatic, 463
 - lymphatic, right, 215, 313, 430
 - Müllerian, 508
 - naso-lacrimal, 502
 - semicircular, 416
 - thoracic, 28, 218, 312, 430, 434
 - thyreo-glossal, 503
 - venosus, 510
 - vitello-intestinal, 499
 - Wolffian, 507
- DUCTLESS GLANDS**, 492
- Duodenum**, 453
- Dura mater**, 357, 358 ,

Ear, 409, 516

Ectoderm, 494, 498

EMBRYOLOGY, 494

Eminence, arcuate, 48

- collateral, 350
- genital, 506
- frontal, 36
- ileo-pectineal, 66, 68
- parietal, 39

Eminentia cruciata, 48

medialis, 333

Encephalon, 323, 513

Entoderm, 494, 498

Ependyma, 332, 512

Epididymis, 481, 507

Epiglottis, 418, 502

Epiphyses, 3

Epistropheus, 8, 17

Epithalamus, 337, 514

Ep-oöphoron, 487, 507

Ethmoid bone, 32, 37, 46, 50,

51

Excavatio. See **Pouch**

Eye-ball, 404, 515

Eyelids, 407

Face, growth of, 518

Falx cerebelli, 358

cerebri, 357

inguinalis, 244

Fascia or Fasciæ, 124

of abdomen, 240

of arm, 136

of axilla, 127

of back, 191

bieipital. See **Lacertus fibrosus**

bucco-pharyngeal, 196, 440

bulbi, 235

of buttock, 159

cervical, 226, 227

coraco-clavicularis, 127

eremasterie, 244

erilbrosa, 164

dentata, 346

diaphragmatis pelvis, 249

urogenitalis, 247

of foot, 173, 174, 181, 188

of forearm, 138

of hand, 139, 147, 156

of head and neck, 195

iliaca, 240

infundibuliform, 240, 245

lata, 159

of leg, 173

lumbo-dorsal, 191

of orbit, 235

palmar. See **Aponeurosis**

parotideo-masseterica, 195

pectinea, 160

pelvis, 248, 249

of perineum, 246

pharyngo-basilar, 201

phrenico-pleural, 425

plantar. See **Aponeurosis**

pretracheal, 196, 211

prevertebral, 196

semilunar. See **Lacertus**

fibrosus

Sibson's, 209

spermatic, 243, 245

temporal, 195

of thigh, 159

transversalis, 240

Fascia or **Fasciæ** (*contd.*)—
triangular. *See* Lig. inguinale
reflexum

Fasciculus or **fasciculi**. *See*
also **Tract** and **Fibres**

of brain and spinal medulla,

321, 354

cerebello-olivary, 327

longitudinals inferior, 354

medialis, 328

superior, 354

occipito-frontalis, 354

pedunculo-mamillaris, 336

retroflexus, 337

thalamo-mamillaris, 330

uncinatus, 354

Fasciola cinerea, 345

FEMALE GENITAL ORGANS, 486

Femur, 73

Fenestra cochleæ (rotunda), 39

vestibuli (ovalis), 39

Fertilisation of ovum, 494

Fibres, arcuate, 326, 327, 355

association, 354

commissural, 354

projection, 354

Fibro-cartilages, intervertebral,

89, 496

Fibula, 79

Fillet. *See* Lemniscus

Filum terminale, 361

Fimbria hippocampi, 349

Fissura, **Fissure**, or **Fissures**—

auricular. *See* F., tympano-
mastoid

calcarine, 344

calloso-marginal. *See* Sulcus
cinguli

cerebri lateralis, 340, 514

chorioidal, 350

collateral, 341

dentate. *See* F. hippocampi

of ductus venosus, 462

fimbrio-dentate, 349

Glaserian. *See* F., petro-
tympanic

hippocampi, 346

Fissura, **Fissure**, or **Fissures**
(*contd.*)—

longitudinal, of brain, 339

orbital, inferior, 37, 40, 41,

43

superior, 37, 47

parieto-occipital, 341

petro-tympanic, 44, 45

portal. *See* Porta hepatis

pterygoid, 32, 42

pterygo-maxillary, 40, 41

of Rolando. *See* Sulcus cen-
tralis

sphenoidal. *See* F. orbital,
superior

spheno-maxillary. *See* F.
orbital, inferior

of Sylvius. *See* F. cerebri
lateralis

transverse, of brain, 351

tympano-mastoid, 39

Flexure or **Flexures**—

of brain, 513

of colon, 457

duodeno-jejunal, 454

Floor of pelvis, 250

Fetal circulation, 511

Fold or **Folds**. *See also* **Plicæ**

ary-epiglottic, 420, 502

cæcal, 459

caudal, 495

cephalic, 495, 497

gastro-pancreatic, 468

glosso-epiglottic, 418

ileo-cæcal, 459

ileo-colic, 459

medullary, 495

pharyngo-epiglottic, 418

recto-uterine, 469

sacro-genital, 469

salpingo-pharyngeal, 447

Fontanelles. *See* Fonticulus

Fonticulus, 38, 39, 41, 517

Foot and toes, 180

Foramen or **Foramina**—

alveolaria, 40

cæcum of skull, 46

Foramen or Foramina (*contd.*)—

- condyloid, anterior. *See* Canal, hypoglossal
- posterior. *See* Canal, condyloid
- epiploicum, 471
- ethmoidal, 37, 46
- incisivum, 42
- infra-orbital, 38
- interventricular, 338, 514
- intervertebral, 6, 16
- jugular, 45, 48
- lacerum, 42, 44, 47
- Magendii. *See* Apertura medialis ventriculi quarti
- magnum, 30, 43, 48
- nastoid, 41, 44, 49
- mental, 34
- of Monro. *See* F., interventricular
- obturatum, 66, 69
- optic, 31, 37, 47
- ovale of sphenoid, 43, 47
- palatine, 42, 43
- parietal, 41, 517
- rotundum, 40, 47
- sacro-sciatic. *See* F., sciatic
- of Scarpa, 42, 50
- sciatic, 109
- spheno-palatine, 40, 50
- spinosum, 43, 47
- of Stenson, 42, 50
- stylo-mastoid, 45
- supra-orbital, 36
- transversarium, 6, 7
- Vesalii, 43
- of Winslow. *See* F. epiploicum
- zygomatiko-faciale, 38
- zygomatiko-orbitale, 38
- zygomatiko-temporale, 39
- Forceps major and minor, 347
- Formatio reticularis. *See* Substantia
- Fornix cerebri, 348, 514
- Fossa or Fossæ**, cæcal, 450
- canine, 38
- cerebellar, 48

Fossa or Fossæ (*contd.*)—

- cloacal, 506
- condyloid, 44
- cranii, 46, 47, 48
- cubital, 145
- digastric, 35
- ductus venosi, 462
- duodenal, 454
- glandulæ lacrimalis, 37
- glenoid, 45
- hypophyscos, 47
- iliac, 67
- incisor, 34, 38
- infra-temporal, 40
- interpeduncular, 334
- intersigmoid. *See* Recess
- ischio-rectal, 249
- jugular, 46
- lacrimal, 37
- lateralis Sylvii, 514
- mandibular, 45
- navicularis, 480, 494
- ovalis (of thigh), 160, 165
- para-duodenal, 454
- para-rectal, 459
- popliteal, 178
- pterygoid, 32, 42
- pterygo-palatine, 40
- rhomboidea, 332
- scaphoid, 42
- spheno - maxillary. *See* F., pterygo-palatine
- subarcuate, 49
- supra-tonsillar, 448, 503
- temporal, 39
- venæ cavæ, 462
- umbilicalis, 461
- zygomatiko. *See* F., infra-temporal
- Fovea** dentis, 7
- pterygoidea, 35
- sublingualis, 35
- submaxillaris, 35
- trochlearis, 37
- Foveolæ granulares, 49
- Frenulum** of Giacomini, 346
- labii, 440

Frenulum linguae, 441
Frontal bone, 29, 36, 37, 38, 39, 41, 46, 49, 50
Furcula, 502
Galea aponeurotica, 228
Gall-bladder, 463
Gamete, 494
Ganglion or **Ganglia**—
 basal, 351
 ciliary, 385
 coeliac, 402
 Gasserian. *See* G., semilunar
 geniculi, 390, 391
 inpar, 399
 interpeduncular, 335
 lenticular. *See* G. ciliary
 Meckel's. *See* G., spheno-palatine
 otic, 388
 semilunar (Gasserian), 384
 semilunar. *See* G., coeliac
 spheno-palatine, 386
 spinal, 362, 496
 spiral, 391
 submaxillary, 226, 389
 sympathetic, 400, 496
 vestibular, 391
Gingivæ. *See* Gums
Glabella, 36
Gland or **Glands**—
 of Bartholin. *See* G., vestibular
 buccal, 440
 bulbo-urethral (Cowper's), 484, 508
 carotid. *See* Glomus caroticum
 mammary, 491
 parathyroid, 493, 503
 parotid, 444
 sublingual, 224, 446
 submaxillary, 223, 446
 suprarenal, 493, 496
 thyroid, 210, 503
 vestibular, 490, 508
Globus pallidus, 352
Glomus caroticum, 493
 coccygeum, 493

Groove, basilar, 329
 carotid, 47
 infra-orbital, 38
 lacrimal, 38
 for lateral sinus, 48
 mylohyoid, 35
 neural, 495
 popliteal, 74
 primitive, 495
Gubernaculum, 507
Gums, 444

Gyrus or **Gyri**—
 angular, 343
 centralis, 343, 344
 fornicatus, 345
 frontal, 342
 fusiform, 345
 hippocampi, 345
 lingual, 345
 marginal, 344
 orbital, 344
 post-parietal, 343
 rectus, 344
 subcallosus, 345, 515
 supra callosal, 345
 supra-marginal, 343
 temporal, 342
 transverse, 342

Habenule, 337
Hand, 145
Hare-lip, 502
Heart, 253, 509
Hepar. *See* Liver
Hiatus canalis facialis, 48
 interosseus, 102
 semilunaris, 50
Hip-bone, 66
Hippocampus, 350
Humerus, 55
Humor, aqueous, 407
Hymen, 489
Hyoid bone, 35, 504
Hypophysis, 335
Hypothalamus, 335, 513

Ileum, 454

Ilium, 66
 Impressio trigemini, 48
 Incus, 413
 Infundibulum of brain, 335
 ethnoidale, 51
 Inion, 41
 Innominate bone. *See* Hip-bone
 Insula, 343, 514
 Intestine, 453, 455, 505
 Iris, 406, 515
 Ischium, 67
 Island of Reil. *See* Insula
Isthmus faucium, 441
 gyri fornicati, 345
 pharyno-nasalis, 447
 rhombenecephali, 333
 Jejunum, 454
Joint or Joints—
 acromio-clavicular, 97
 ankle, 119
 carpal, 106
 carpo-metacarpal, 106
 costo-sternal, 95
 costo-vertebral, 94
 development of, 519
 elbow, 100
 of foot, 120
 hip, 111
 interchondral, 95
 intermetacarpal, 106
 intermetatarsal, 122
 interphalangeal, 108, 123
 knee, 114
 mandibular, 92
 metacarpo-phalangeal, 107
 metatarso-phalangeal, 123
 of pelvis, 108
 radio-carpal, 103
 radio-ulnar, 101, 102
 of ribs and costal cartilages,
 95
 sacro-iliac, 109
 shoulder, 98
 sternal, 95
 sterno-clavicular, 97
 tarsal, 120

Joint or Joints (*contd.*)—
 tibio-fibular, 118
 of vertebral column, 89
 of vertebral column with
 cranium, 91
 wrist. *See* J., radio-carpal

Kidney, 474, 507

Labia majora and minora, 490
 oris. *See* Lips

Labrum glenoidale, 98, 111

Lacertus fibrosus, 137

LACRIMAL APPARATUS, 408

Lacrima bone, 33, 37, 50

Lacunæ laterales, 360
 urethrales, 480

Lambda, 41

Lamella, costo-transverse, 6, 7

Lamina, alar, 512

 basal, 512

 cinerea. *See* L. terminalis

 papyracea, 32, 37

 terminalis, 336, 513

Larynx, 417, 502, 504

Lemniscus lateralis, 392
 medialis, 356

Lens crystallina, 407, 515

Lien. *See* Spleen

Ligaments, Ligamenta—

 alaria, 91

 annular radii, 101

 apicis dentis, 91

 arcuatum pubis, 110

 arteriosum, 261, 509

 bifurcatum, 121

 of bladder, false, 469

 broad, of uterus, 469

 carpal, dorsal, 139, 156

 transverse, 138, 147

 volar, 138, 147

 check. *See* L. alaria

 colli costæ, 95

 conoid, 98

 coraco-acromial, 98

 coraco-clavicular, 98

 coraco-humeral, 99

Ligaments, Ligamenta (*contd.*)

coronary, 468, 505
 costo-clavicular, 97
 costo-colic. *See* L., phrenico-colic
 costo-coracoid, 127
 cruciatum of atlas, 91
 cruciatum cruris, 174, 188
 deltoïd, 119
 denticulatum, 361
 falciform, 467
 flava, 89
 gastro-colic, 467
 gastro-lienale. *See* L., gastro-splenic
 gastro-phrenic, 452, 468
 gastro-splenic, 452, 468, 504
 Gimbernat's. *See* L. lacunare
 hepato-colic, 468
 hepato-duodenale, 465
 hepato-gastricum, 465
 ilio-lumbar, 108
 inguinale, 241
 reflexum, 241
 interclavicular, 97
 lacunatum, 174, 182
 lacunare, 243
 latum uteri, 469
 lieno-renal, 468, 504
 longitudinal, 89
 lumbo-costal, 94
 lumbo-sacral, 90
 malleoli lateralis, 119
 nuchæ, 91
 orbicular. *See* L. annulare
 radii
 ovarii proprium, 488
 patellæ, 114
 of pelvis, 108
 phrenico-colic, 468
 plantar, long, 122
 Poupart's. *See* L. inguinale
 pterygo-spinosum, 94
 pubo-prostatic, 249, 252
 pubo-vesical, 249, 252
 pulmonale, 424
 radiatum, 94

Ligaments, Ligamenta (*contd.*)

round. *See* L. teres
 sacro-sciatic. *See* L. Sacro-spinosum and tuberosum
 sacro-spinosum, 108
 sacro-tuberosum, 108
 of scapula, 98
 spheno-mandibulare, 92, 503
 stellate. *See* L. radiatum
 sterno-pericardial, 260
 stylo-hyoid, 94, 226
 stylo-mandibular, 94, 195
 subflava. *See* L. flava
 subpubic. *See* L. arcuatum
 suspensory of ovary, 469
 of penis, 484
 teres femoris, 112
 hepatis, 467, 510
 uteri, 488
 transverse, of atlas, 91
 transversum cruris, 174
 trapezoid, 98
 triangular, of liver, 468, 505
 triangular, of perineum. *See* Fasciæ diaphragmatis urogenitalis
 venosum, 467, 510
 ventriculare, 419
 of vertebral column, 89
 vocale, 419
 Limbs, development of, 518
 Limbus fossæ ovalis, 256
 Limen insulæ, 346
Line or Linea—
 alba, 240
 arcuate, 67
 aspera, 75
 epiphyseal, 3
 gluteal, 66
 ilio-pectineal, 68
 median, of neck, anterior, 226
 mylo-hyoid, 34
 nuchal, 41
 pectineal, 68
 popliteal, 78
 semicircularis, 241
 semilunaris, 241

Line or Linea (*contd.*)—

splendens, 361

temporal, 36, 39

terminalis, 71

Lingula sphenoidalis, 47

Lip, rhombic, 513

Lips of mouth, 440

Liver, 461, 505

Lobule, paracentral, 344

parietal, 343

Locus cœruleus, 333

perforatus. *See* Substantia

Lung, 209, 434, 502

relations of, 436

root of, 438

Lymph of brain, 353

LYMPH GLANDS, 313

LYMPHATIC SYSTEM, 312

Malar bone. *See* Zygomatic

MALE GENITAL ORGANS, 480

Malleoli, 78, 79

Malleus, 413

Mammæ, 491

Mandible, 34, 40

Margin, nasal, 29, 36

supra-orbital, 36, 37

Massa intermedia, 336, 338

Maxilla, 33, 37, 38, 40, 42, 50

Meatus acusticus externus, 39,

410, 503

internus, 49, 416

Meatus nasi, 50

Mediastinum, anterior, 425

middle, 425

posterior, 425, 431

superior, 425, 426

Medulla oblongata, 325, 513

spinalis, 319, 512

Membrana, Membrane—

atlanto-occipital, 91

bucco-pharyngeal, 497, 501

cloacal, 506

costo-coracoid, 127

intercostal, 237

interosseous, of forearm, 102

of leg, 118

Membrana, Membrane (*contd.*)

obturator, 69

pupillary, 515

sterni, 95

tectoria, 91

thyreo-hyoid, 419

tympani, 411, 503

Membranes, fœtal, 498

Meninges, 357

Mesencephalon, 333, 513

Mesenteriolium processus verni-
formis, 467

Mesentery, 467

Meso-colon, 467

Mesoderm, 494, 496, 500

Meso-gastrium, 504, 505

Meso-inetrium, 469

Meso-nephros, 507

Meso-salpinx, 469

Mesovarium, 469

Metacarpus, 64

Metatarsus, 84, 86

Metathalamus, 337, 514

Mid-brain. *See* Mesencephalon

Modiolus, 415

Mons Veneris, 490

Morula, 494

Mouth, 439, 501

Movements in respiration, 96

Muscle or Muscles, 124

of abdominal wall, 240

abductor digiti quinti, of foot,
183

of hand, 149

abductor hallucis, 182

pollicis brevis, 149

longus, 143, 157

accessorius, of foot. *See* M.
quadratus plantæ

adductor hallucis, 184

pollicis, 149

of thigh, 163

anconæus, 143

articularis genu, 161

auriculares, 228

of back, 192, 196

biceps brachii, 137

Muscle or Muscles (*contd.*)—

- biceps femoris, 172
- brachialis, 137
- brachio-radialis, 142
- buccinator, 233
- bulbo-cavernosus, 248
- chondro-glossus, 199
- ciliaris, 406
- classification, of lower limb, 190
- of upper limb, 158
- coccygeus, 249
- complexus. *See* Semispinalis capitis
- constrictors, 200
- coraco-brachialis, 137
- corrugator cutis ani, 247
- cremaster, 244
- crureus. *See* M. vastus
- dartos, 240, 480
- deltoid, 128
- diaphragm, 238
- digastric, 198
- dilatator pupillæ, 406
- of ear, 228
- epicranius, 228
- erector penis. *See* M. ischio-cavernosus.
- spinæ. *See* M. sacro-lumbalis
- extensor carpi radialis brevis, 142, 157
- longus, 142, 157
- carpi ulnaris, 143, 157
- digitu quinti proprius, 143, 157
- digitorum brevis, 189
- communis, 142, 157
- longus, 174, 188
- hallucis longus, 175, 188
- indcis proprius, 144, 157
- ossis metacarpi pollicis. *See* M. abd. poll. long.
- pollicis brevis, 144, 157
- longus, 144, 157
- of eyelids, 231
- of face, 228

Muscle or Muscles (*contd.*)—

- flexor carpi radialis, 139, 156
- carpi ulnaris, 140
- digitu quinti brevis, of foot, 185
- of hand, 150
- digitorum brevis, 183
- longus, 177, 183
- profundus, 141, 152
- sublimis, 140, 152
- hallucis brevis, 184
- longus, 177, 184
- pollicis brevis, 149
- longus, 141, 153
- gastrocnemius, 176
- gemelli, 172
- genio-glossus, 199
- genio-hyoid, 198
- glosso-palatinus, 199
- glutæi, 170, 171
- gracilis, 163
- hamstring, 172
- of head, 228
- hyo-glossus, 199, 222
- of hyoid bone, 197
- iliacus, 162
- ilio-costalis, 192
- infra-spinatus, 129
- intercostals, 237
- interossei, 155, 187
- interspinales, 194
- intertransversales, 194
- ischio-cavernosus, 248
- of larynx, 421
- latissimus dorsi, 125
- levator ani, 248, 250
- glandulæ thyroideæ, 198
- palpebræ superioris, 236
- scapulae, 126
- veli palatini, 201
- levatores costarum, 23
- longissimus, 193
- longus capitis, 203
- colli, 203, 209
- lumbricales, 152, 183
- masseter, 233

Muscle or Muscles (*contd.*)—

- of mastication, 233
- of mouth, 232
- multifidus, 193
- mylohyoid, 198, 222
- of nose, 232
- obliqui capitis, 194
 - abdominis, 241, 243
 - of eyeball, 236
- obturator externus, 164
 - internus, 171
- omo-hyoid, 197, 209
- opponens digiti quinti, 150
 - pollicis, 149
- orbicularis oculi, 231
 - oris, 232
- palato-glossus. *See* M. glosso-palatinus
- palato-pharyngeus. *See* M. pharyngo-palatinus
- palmaris brevis, 147
 - longus, 140
- pectineus, 162
- pectoralis, 126, 127
- of pelvis, 248
- of perinæum, 246
- peronæi, 175, 187, 189
- pharyngo-palatinus, 201
- of pharynx, 200
- piriformis, 171
- plantaris, 176
- platysma, 232
- popliteus, 176
- prevertebral, 203
- pronator quadratus, 141
 - teres, 139
- psoas, 162
- pterygoidei, 233, 234
- pyramidalis abdominis, 241
- pyriformis. *See* M. piriformis
- quadratus femoris, 172
 - labii, 232
 - lumborum, 246
 - plantæ, 183
- quadriceps femoris, 161
- recto-urethralis, 460
- rectus abdominis, 241

Muscle or Muscles (*contd.*)—

- rectus capitis anterior, 204
 - lateralis, 203
 - posterior, 194
- of eyeball, 236
 - femoris, 161
- of respiration, 237
- rhomboidei, 126
- risorius, 232
- rotatores, 193
- sacro-spinalis, 192
- salpingo-pharyngeus, 201
- sartorius, 160
- scaleni, 202, 203
- of scalp, 228
- seminembranosus, 173
- semispinalis, 192
- semitendinosus, 172
- serrati posteriores, 192
- serratus anterior, 127
- of soft palate, 201
- soleus, 176
- sphincter ani, 248
 - pupillæ, 406
 - urethræ, 248
 - vaginæ. *See* M. bulbo-cavernosus
- spinalis, 193
- splenius, 192
- stapedius, 414
- sterno-hyoid, 197, 209
- sterno-mastoid, 196
- sterno-thyreoid, 197, 209
- stylo-glossus, 199
- stylo-hyoid, 198
- stylo-pharyngeus, 200
- subanconæus, 138
- subclavius, 127
- subcostals, 237
- suberureus. *See* M. articularis genu
- subscapularis, 129
- supinator, 143
 - longus. *See* M. brachio-radialis
- supraspinatus, 128
- temporal, 233

Muscle or Muscles (*contd.*)—

- tensor fasciæ latæ, 171
- tympani, 414
- veli palatini, 202
- teres major, 129
- minor, 129
- thyreo-hyoid, 197
- tibialis anterior, 174, 188
- posterior, 177, 187
- of tongue, 199
- trachelo - mastoid. *See* M.
longissimus capitis
- transversus abdominis, 244
- perinæi, 248
- thoracis, 237
- trapezius, 125
- triangularis, 232
- sterii. *See* transversus
thoracis
- triceps brachii, 137
- suræ, 175
- uvulæ, 201
- vasti, 161
- zygomaticus, 232

Nares, anterior. *See* Apertura
piriformis

posterior. *See* Choanæ

Nasal bone, 33, 38, 50

Nasion, 36

Navicular bone of foot, 83, 86

of hand, 62

Neck, root of, 209

Nerve or Nerves, nervus, 362

abducent, 389

accessory, 206, 221, 397

acoustic, 391

alveolar, 386, 388

anterior crural. *See* N., femoral

auricular, great, 206, 229, 365

posterior, 390

of vagus, 395

auriculo-temporal, 229, 388

axillary, 135, 371

buccinator, 387

calcanean, 181, 379

cardiac, 215, 221, 430

Nerve or Nerves (*contd.*)—

cerebral, 324, 382

cervical, 363, 364

chorda tympani, 390

ciliary, 385, 386

circumflex. *See* N., axillary

coccygeal, 250

cochlear, 391

cutaneous, of arm, 134, 135,

136, 370, 371

of forearm, 134, 136, 138,

368, 370, 371

palmar, 146, 147, 369, 370

perforating, 159, 251, 380

of thigh, 159, 165, 166, 173,

180, 251, 374, 375, 376,

377

cutaneus colli, 207, 365

dental. *See* N., alveolar

descendens cervicalis, 366

hypoglossi, 221, 398

dorsalis penis, 381

scapular, 208, 367

ethmoidal, 385

facial, 229, 389

femoral, 166, 375

frontal, 385

genito-femoral, 165, 374

glosso-pharyngeal, 226, 393

gluteal, 251, 377

hemorrhoidal, 380

hypoglossal, 221, 226, 398

ilio-hypogastric, 159, 374

ilio-inguinal, 159, 165, 374

infra-orbital, 386

infra-trochlear, 385

intercostal, 373

intercosto-brachial, 132, 136,

373

intermedius, 391

interosseous, dorsal, 372

volar, 369

ischiadicus. *See* N., sciatic

lacrimal, 385

laryngeal, external, 211, 221,

396

inferior, 215, 396

Nerve or Nerves (contd.)—

- laryngeal, internal, 221, 396
 - superior, 396
- lingual, 225, 388
- lumbar, 364, 373
- lumbo-inguinal, 159, 374
- mandibular, 387
- maxillary, 386
- median, 134, 151, 368
- mental, 388
- musculo-cutaneous, 134, 138, 368
 - of leg. *See* N., peroneal, superficial
- musculo-spiral. *See* N., radial
- mylo-hyoid, 388
- naso-ciliary (nasal), 385
- naso-palatine, 387
- obturator, 159, 375
- to obturator internus, 377
- occipital, greater, 229, 363
 - lesser, 206, 229, 365
 - third, 229, 361
- oculo-motor, 382
- olfactory, 381, 515
- ophthalmic, 385
- optic, 381
- palatine, 387
- perineal, 250, 380
- peroneal, common, 179, 378
 - deep, 188, 190, 378
 - superficial, 173, 188, 378
- petrosal, 390, 394
- pharyngeal, 387
- phrenic, 28, 214, 217, 366, 429
- to piriformis, 377
- plantar, 185, 186, 379
- pneumogastric. *See* N., vagus
- popliteal. *See* Nn., peroneal and tibial
- of pterygoid canal, 387, 390
- pudendal, 380
- to quadratus femoris, 377
- radial, 135, 138, 371
- recurrent (laryngeal), 28, 215, 218, 396, 430

Nerve or Nerves (contd.)—

- to rhomboids. *See* N., dorsalis scapulae
- sacral, 364, 373
 - fifth, 250
- saphenous, 166, 173, 181, 376
 - short. *See* N. suralis
- sciatic, 251, 377
 - small. *See* N., cutaneous, posterior, of thigh
- spermatic, external, 374
- spheno-palatine, 386
- spinal, 362
- spinal accessory. *See* N., accessory
- splanchnic, 401
 - to subclavius, 208, 367
- subscapular, 135, 370
- supra-clavicular, 207, 365
- supra-orbital, 229, 385
- supra-seapular, 208, 367
- supra-trochlear, 229, 385
- sural, 173, 179, 378, 379
- suralis, 173, 181, 188, 379
- sympathetic, 399
- temporal, deep, 387
- thoracic, 364, 372
 - anterior, 134, 368
 - first, 28, 215, 373
 - long, 134, 208, 367
- thoraco-dorsal, 135, 370
- tibial, 179, 379
- trigeminal, 383
- trochlear, 383
- tympanic, 394
- ulnar, 135, 151, 369
- vagus, 28, 214, 217, 221, 394, 430, 432, 433
- vestibular, 391
- Vidian. *See* N. of pterygoid canal
- zygomatic, 386
- Nerve-roots, 321, 362, 363
- Nervous system, central, 319, 512
 - peripheral, 362
- Neuroblasts, 512
- Neuroglia, 318, 512

- NEUROLOGY, 318
 NOSE, 38, 50, 403, 501, 502, 517
Notch—
 clavicular, 18
 ethmoidal, 29
 fibular, 78
 jugular, 18, 44
 nasal, 29
 popliteal, 77
 pre-occipital, 337
 radial, 57
 sciatic, 66, 67
 semilunar, 57
 spheno-palatine, 34
 supra-orbital, 36
 for trigeminal nerve, 49
 ulnar, 59
Notochord, 496
Nucleus ambiguus, 327, 393
 amygdalæ, 352
 arcuatus, 327
 of Bechterew, 392
 caudatus, 351, 514
 cuneatus, 325, 327, 513
 of Denters, 392
 dentatus, 331
 emboliformis, 331, 392
 fastigii, 331, 392
 globosus, 331, 392
 gracilis, 325, 327, 513
 habenulæ, 337
 hypothalamicus, 335
 lateralis, 327
 lentiformis, 351, 514
 olivaris inferior, 326, 327, 513
 superior, 392
 red (ruber), 334
 roof. *See* N. fastigii
Nymphæ. *See* Labia minora
 Obelion, 41
 Occipital bone, 30, 38, 41, 43, 49
 Oesophagus, 27, 210, 429, 432,
 449, 504
 Olecranon, 57
 Olva, 326
 Omenta, 452, 465, 466, 505
 Opercula, 343
 Ora serrata, 406
 Orbit, 36, 46
 ORGANS OF THE SENSES, 403
 Os coxæ. *See* Hip-bone
 trigonum, 81, 86
 Ossa suturarum, 517
 Ossicles, auditory, 413
 OSTEOLGY, 1
 Ovary, 486, 507
 Palate, 42, 441, 502
 Palatine bone, 34, 37, 40, 42,
 43, 50
 Palm, 146
 Palpebræ. *See* Eyelids
 Pancreas, 464, 505
 Panniculus adiposus, 124
 Parachidymis, 482, 507
 Parametrium, 488, 489
 Parietal bone, 30, 38, 39, 41, 47,
 48, 49
 Par-oophoron, 487, 507
 Parovarium. *See* Ep-oophoron
 Pars intermedia. *See* Nervus
 intermedius
 Patella, 77
 Pedunculus cerebri, 334, 513
 thalami inferior, 336
 Pelvis, 71, 451
 movements and mechanism of,
 110
 Penis, 484, 506
 Pericardium, 260, 497, 508
 Perineum, 246
 PERIPHERAL NERVOUS SYSTEM,
 362
 Peritoneum, 465
 great sac of, 470
 Phalanges, 65, 85, 86
 Pharynx, 446
 Philtrum, 440, 501
 Pia mater, 360
 Pineal body, 337
 Pit, olfactory, 501, 514
 of stomach, 19
 Pituitary body. *See* Hypophysis

Placenta, 498, 499, 500

Planes of abdomen, 450

Plate, basi-cranial, 517

ethmoidal, 517

tympenic, 31, 45, 518

Pleura, 26, 209, 423, 436

Plexus or Plexuses—

aortic, 402

basilar, 304

brachial, 133, 207, 367

cardiac, 401

carotid, 400

cavernous, 400

cervical, 365

chorioid, 360

coecygeal, 381

cœliac, 402

coronary, 401

gastric, 395, 397

hypogastric, 402

lumbar, 374

lumbo-sacral, 373

obturator, 167, 376

œsophageal, 395, 396

pampiniform, 308

patellar, 376

pelvic, 402

prostatic, venous. *See* Pl.,

pudendal

pterygoid, venous, 302

pudendal, nervous, 380

venous, 309

pulmonary, 395, 396

sacral, 376

solar. *See* Pl., cœliac

subsartorial. *See* Pl., obturator

sympathetic, 401

tympenic, 394

vertebral, 305

Plica or Plicæ. *See also* Fold

alares, 116

circulares, 455

epigastrica, 468

fimbriata, 442

palmatæ, 488

sublingualis, 441

umbilicales, 468

Plica or Plicæ (contd.)—

ventricularis, 420

vesicalis transversa, 469

vocalis, 420

Point, Sylvian, 340

Pons (Varolii), 329, 513

Porta hepatis, 462

Post-anal gut, 506

Pouch, recto - vaginal (Douglas),

469

recto-vesical, 469

utero-vesical, 469

visceral, 502

Præcuneus, 344

Process or Processes, Processus—

angular, medial, 29, 36

auditory, 45

ciliary, 406

clinoid, 31, 47

coracoid, 53

frontal, 33, 37, 38

fronto-nasal, 501

fronto-sphenoidal, 34, 39

globular, 501

jugular, 30, 44, 47

mastoid, 31

maxillary (fœtal), 501, 503

nasal (fœtal), 501

odontoid, 8, 17

orbital, 34, 37, 40

palatine, 33, 42, 50

petrosal, 47

pterygoid, 32, 40, 42, 50

pyramidal, 34, 40, 43

sphenoidal, 34, 40

styloid, of temporal bone, 31, 45

temporal, 34

trochlear, 82

vaginal, 42, 469, 507

vermiform, 456, 506

xiphoid, 18, 19

zygomatic, 29, 30, 33, 36, 37,

38, 39, 43

Proctodæum, 506

Pronation, 103

Prostate, 483, 508

- Protuberance, mental, 34
 occipital, 41, 48
 Pterion, 38
 Pubis, 67
 Pudendum muliebre, 490
 Pulvinar, 336
 Putamen, 352
 Pylorus, 451
- Radiation**, acoustic, 392
 optic, 382
 Radius, 59
 Rami anteriores, 364-381
 posteriores, 363
 Ramus anastomoticus peronæus,
 173, 180, 378
 Receptaculum chyli. *See* Cisterna
- Recess, Recessus**—
 ileo-cæcal, 459
 intersigmoid, 459
 pharyngeal, 447, 503
 piriformis, 420, 503
 retro-cæcal, 459
 sacciformis, 102
 of third ventricle, 338
 Rectum, 459, 500
 Region, sublingual, 440
 subthalamie, 335
 Ren. *See* Kidney
 Respiration, movements of, 96
 RESPIRATORY APPARATUS, 417
 Restiform body, 325, 327, 513
 Retina, 406, 515
 Retinacula, peroneal, 174
 Rhinencephalon, 346
 Rib, cervical, 9, 17
 lumbar, 17
 Ribs, 19, 23, 516
 movements of, 95
- Rima** glottidis, 420
 pudendi, 490
- Ring**, femoral (crural), 167
 inguinal, 243, 245
- Saphenous opening. *See* Fossa ovalis
 Scalp, 228
 Scapula, 53
 Sclera, 405, 515
 Scrotum, 480
 Sella turcica, 47
 Sense organs, 403
- Septum**, femoral (crural), 167
 intermuscular, of arm, 136, 137
 of foot, 174
 of leg, 173
 of palm, 139, 148
 of thigh, 160
 mediastinal, 423, 436
 pectiniforme, 485
 pellucidum, 349, 514
 transversum, 505, 508
- Sesamoid bones, 2, 65, 86, 149
- Sheath**, axillary, 130, 196
 carotid, 196
 femoral, 160, 167
 fibrous flexor, 139, 148, 182
 mucous or synovial, 141, 144, 153, 184
 of rectus, 244
- Sinus** arcuatus, 502
 basilar. *See* Plexus
 cervical, 504
 coronary, 298, 510
 costo-mediastinal, 424
 cranial blood, 303
 epididymidis, 481
 frontal, 30, 46, 50
 maxillary, 33, 50
 parasinoidal, 360
 phrenico-costal, 424
 prostatic, 479
 rectales, 460
 sphenoidal, 50, 51
 tarsi, 82
 venosus, 509, 510
 venous, of cranium, 303
 vertebral, 305
- Skeleton, 1
 Skull, 29, 519
 growth of, 518
- Saccule, 416
 Sacrum, 13, 17

- Slit, nasal, 46
 Sole of foot, 181
 Somites, 497
Space, Spaces—
 interpeduncular. *See* Fossa
 quadrilateral, 130
 retro-pharyngeal, 196
 of Retzius, 249
 submaxillary, 222
 triangular, 130
 Sphenoid bone, 31, 37, 38, 39,
 40, 42, 43, 46, 47, 48,
 50, 51
Spina or Spine—
 angular, 43
 ethmoidal, 46
 mental, 34
 nasal, anterior, 38
 posterior, 42
 supra meatum, 39
 trochlearis, 37
 Spinal medulla, 319, 512
 Spleen, 492, 504
 Spongioblasts, 512
 Stalk, body, 495
 Stapes, 413
 Stephanion, 39
 Sternum, 18, 516
 Stomach, 451, 504
 Stomodæum, 501
 Streak, primitive, 494, 495
Stria or Striæ—
 of Gennari, 353
 longitudinales, 345
 medullares, 337
 terminalis, 350
Substance, Substantia—
 gelatinosa Rolandi, 320
 nigra, 334
 perforata anterior, 346, 515
 posterior, 324
 reticularis, 328
 white, of hemisphere, 354
 Subthalamie region, 335
 Suetorial pad, 195, 440
Sulcus or Sulci. *See also* Groove
 alar, 403
Sulcus or Sulci (contd.)—
 centralis (Rolandi), 340
 chiasmatis, 47
 cinguli, 341
 circularis, 343
 corporis callosi, 341
 frontal, of brain, 342
 hypothalamicus, 338, 512
 intermedius, 452
 interparietal, 343
 intertubercular, 55
 mylo-hyoid, 35
 oculo-motor, 334
 oculo-nasal, 502
 olfactory, 344
 orbital, 344
 petrosal, 48, 49
 precentral, 342
 pulmonalis, 26
 ii. radialis, 56
 sagittal, 46
 subparietal, 341
 temporal, 342
 terminalis, 255, 442, 502,
 510
 tubæ auditivæ, 44
 Supination, 103
 Sustentaculum tali, 82
Suture, 87
 coronal, 41, 49, 518
 frontal, 36
 lambdoid, 41, 49, 518
 metopic, 518
 palatine, 42
 sagittal, 41, 49, 518
 squamous, 49, 518
 Swallowing. *See* Deglutition
 SYMPATHETIC SYSTEM, 399
 cervical ganglia, 215
 Symphysis menti, 34
 pubis, 110
Synchondrosis, 87
 epiphyscal, 3
 neuro-central, 17
 Syndesmosis, 87
 tibio-fibularis, 118
 Synostosis, 87

Tænia semicircularis. *See* *Stria terminalis*
thalami, 337
Talus, 81, 86
Tapetum, 348
Tarsal bones, 81, 86
Teeth, 443
Tegmen tympani, 48
Tegmentum, 334, 513
Tela chorioidea, 360, 514
Temporal bone, 30, 38, 39, 41, 43, 44, 47, 48, 49
Tendo calcaneus (Achillis), 175
Tendon, conjoint. *See* *Falx inguinalis*
Tentorium cerebelli, 357
Testis, 481, 507
Thalamencephalon, 336
Thalamus, 336, 514
Thorax, 25
 inferior aperture of, 28
 superior aperture of, 26, 209
Thymus, 209, 426, 493, 503
Tibia, 77
Tongue, 442, 503
Tonsil, palatine, 447, 503
Torcular Herophili. *See* *Confluens sinuum*
Torus tubarius, 447
Trachea, 27, 210, 422, 428, 502, 504
Tract, Tractus. *See also Fasciculus*
 of brain and spinal medulla, 321, 354
 cortico-pontine, 353
 ilio-tibial, 160
 olfactory, 346, 515
 optic, 335
 solitarius, 393, 513
 spinalis of V., 385
 of spinal medulla, 321, 354
 vestibulo-spinal, 322, 392
Triangle, *anterior, of neck*, 208
 of auscultation, 126
 carotid, 218
 diaphragic, 221

Triangle (contd.)—
 of Hesselbach, 246
 lumbar (Petit), 246
 muscular, 208
 posterior, of neck, 204
 submaxillary, 221
 submental, 222
 sub-occipital, 194
 supra-meatal, 39

Trigonum *collaterale*, 350
 femorale, 164
 habenulæ, 337
 lumbale, 246
 olfactorium, 346, 515
Trochanter, 73, 74
Trophoblast, 494
Truncus arteriosus, 509

Trunk
 broncho-mediastinal, 216, 430
 costo-cervical, 213, 278
 lumbo-sacral, 376
 lymphatic, 313
 sympathetic, 215, 221, 399
 thyreo-cervical, 213, 276
Tube, *auditory (Eustachian)*, 44, 45, 413, 447, 503, 517
 neural, 487, 495, 496, 512
 uterine (Fallopian), 487, 508

Tuber cinereum, 335
 frontale, 36
 maxillare, 33, 40, 42
 parietale, 39
Tubercle, Tuberculum—
 adductor, 74
 amygdaloid, 350
 articulare, 45
 carotid, 7
 cinereum, 325
 cuneate, 325
 deltoid, 52
 impar, 502
 intervenosum (Lower), 256
 jugular, 48
 mental, 34
 pharyngeal, 43
 post-glenoid, 45
 pterygoid, 42

Tubercle, Tuberculum (*contd.*)—

- scaleni, 21
- sellæ, 47
- of zygomæ, 39

Tuberositas, Tuberosity—

- coracoid, 52
- costal, 51
- deltoid, 56
- gluteal, 75
- of maxilla. *See* Tuber

Tunica vaginalis, 481, 507

Tympanum, 410

Ulna, 57

Umbilicus, 241, 495

Uncus, 345

Urachus, 499, 507

Ureter, 476, 507

Urethra, 479, 506

UROGENITAL APPARATUS, 475,
506

Uterus, 487, 508

Utricle, 415

Utriculus prostaticus, 479, 508

Uvula palatina, 441

Vagina, 489, 508

Vaginæ mucosæ, 125, 141, 144,
153

Vallecula Sylvii, 324, 514

Valve, Valves—

- anal, 460
- aortic, 259
- of colon, 456
- of coronary sinus, 256
- Eustachian. *See* V. of vena cava
- mitral, 259
- pulmonary, 258
- tricuspid, 258
- of vena cava inferior, 256

Vein, Veins, Vena, 297, 510

- anastomotic, 303
- angular, 301
- anonyma. *See* V., innominate
- auricular, 231, 302
- axillary, 131, 306
- azygos, 299, 427, 433, 511

Vein, Veins, Vena (*contd.*)—

- basilar, 303
- basilic, 136, 138, 306
- of brain, 303
- bronchial, 299, 423
- cardiac, 298
- oblique, 298, 510, 511
- cardinal, 511
- cava inferior, 307, 511
- superior, 299, 427, 511
- cephalic, 131, 136, 138, 306
- cerebral, 303
- chorioid, 303
- circumflex iliac, deep, 309
- superficial, 310
- coronary, 311
- cystic, 311
- diploic, 302
- dorsal, of clitoris, 309
- of penis, 309
- epigastric, 300, 309, 310
- facial, 220, 302
- femoral, 169, 310
- of forearm, 306
- frontal, 231, 301
- gastric, 312
- hemorrhoidal, 309
- of head and neck, 300
- of heart, 298
- hemiazygos, 299, 433, 434, 511
- hepatic, 308, 510
- hypogastric, 309, 511
- iliac, 308, 309, 511
- ilio-lumbar, 309
- innominate, 28, 214, 217, 300,
426, 511
- intercostal, anterior, 300
- left superior, 300, 426, 511
- posterior, 299
- first or highest, 213, 300
- right superior, 299
- jugular, anterior, 209, 226, 303
- external, 206, 302
- internal, 213, 217, 220, 300,
511
- primitive, 510
- lienalis. *See* V., splenic

Vein, Veins, Vena (*contd.*)—

- lingual, 221, 225
- of lower limb, 309
- lumbar, 308, 511
- mammary, internal, 300
- maxillary, internal, 302
- median, 138, 306
 - basilic, 138, 306
 - cephalic, 138, 306
- meningeal, 302
- mesenteric, 311
- musculo-phrenic, 300
- of nose, 302
- occipital, 231, 302
- ophthalmic, 302
- ovarian, 308
- pancreatico-duodenal, 312
- pharyngeal, 220
- phrenic, 308
- popliteal, 178, 310
- porta, 311, 510
- profunda femoris, 169, 310
- puddental, 309, 310
- pulmonary, 297
- renal, 308, 511
- saphenous, 159, 167, 173, 179, 310
- of scalp, 231, 301
- spermatic, 308
- spheno-palatine, 302
- spinal, 305, 306, 322
- splenic, 311
- striate, inferior, 303
- subcardinal, 511
- subclavian, 206, 214, 217, 301
- supra-orbital, 231, 301, 308
- supra-renal, 308, 511
- Sylvian. *See* Cerebral, middle
- systemic, 298
- temporal, 231, 301
- terminalis, 301
- thyroid, 211, 221, 300, 426
- transverse cervical, 206
 - scapular, 206

Vein, Veins, Vena (*contd.*)—

- umbilical, 510
- of upper limb, 306
- vertebral, 213, 300
- vitelline, 508, 510
- Velum interpositum. *See* Tela chorioidea
- medullare, 331, 513
- palatinum, 441
- Ventricle**—
 - fourth, 332, 513
 - lateral, 349, 514
 - third, 338, 513
- Ventriculus. *See* Stomach
- Vertebra prominens, 8
- Vertebrae, 5, 16
- Vertex, 41
- Vesica fellea, 463
 - urinaria, 477
- Vesicle**, cerebral, 496, 513
 - optic, 515
 - otic, 516
 - seminal, 483, 507
 - umbilical, 494, 495, 498, 499
- Vestibule**, aortic, 259
 - of ear, 414
 - of mouth, 439
 - of vagina, 490
- Vitreous body, 407, 515
 - table, 2
- Vomer, 33, 42, 50
- Vulva, 490
- Wharton's jelly, 500
- White substance of brain, 354
- Wolfian body, 497, 507
- WRIST, HAND AND DIGITS, 145
- Yolk-sac, 494, 495
- Zonula ciliaris, 407
- Zygoma, 30, 39
- Zygomatic bone, 34, 37, 38
- Zygote, 494







